Determinants of Small-Scale Commercial Vegetable Farming Among Vegetable Growers in Nepal

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Abstract
Various socio-economic factors play important roles in the adoption of commercial vegetable farming. Understanding these factors is crucial in enhancing the existing low rate of vegetable commercialization in Nepal, thereby achieving the overall development goal of poverty reduction. This article analyzes the personal, technical, and business factors associated with the adoption using Nepal Vegetable Crops Survey 2009–2010 data. A probit analysis is carried out. Caste/ethnicity is a critical factor hindering the adoption in Nepal. An awareness program to facilitate marketing of vegetables produced by the socially disadvantaged caste/ethnic groups and targeting them in interventions would be helpful in enhancing the rate of vegetable commercialization. Similarly, facilitating access to technical factors, mainly technical assistance, chemical fertilizers, pesticides, and improved seeds, would promote commercial vegetable farming. Such interventions can be introduced in vegetable production potential areas of Hills and Tarai. Land consolidation might not be important. Rather, any program or policies to facilitate secure land-tenure, which encourages farmers to invest in land development, would boost vegetable commercialization. Similarly, identification of vegetable cultivation areas and provision of irrigation in those land parcels would be vital.

Keywords
adoption, business factors, personal factors, probit, technical factors

Introduction
Smallholding subsistence farmers, who are involved in farming only for self-consumption, constitute the majority of 815 million chronically undernourished people in the world (Food and Agriculture Organization of the United Nations, 2017). Around 80% of arable land is cultivated by smallholder farms producing about 80% of food consumed in Africa and Asia, which are also homes to the majority of chronically undernourished people (Food and Agriculture Organization of the United Nations, 2014; Nwanze, 2011). Low-income or lower-middle-income countries in these regions, however, lack structural transformation driven by agricultural productivity. These countries are marred by low agricultural productivity growth resulting in increasing dependence on market purchase, constituting as high as 90% of the food supplies (Food and Agriculture Organization of the United Nations, 2017). Such countries are vulnerable to any threats posed by external shocks such as rise in market food price as experienced in 2007–2008 or the COVID-19 global pandemic that disrupted the trade. The vulnerability can be reduced through significant increment in agricultural productivity of smallholding subsistence agriculture. Agricultural productivity can be increased by encouraging smallholder farmers to pursue sustainable intensification (Baiphethi & Jacobs, 2009). Hence, smallholder farmers need to be the primary driver in agriculture technological transformation (Food and Agriculture Organization of the United Nations, 2017).

Agricultural productivity growth has a proven track record of its contribution to successful economic development with China, South Korea, and Vietnam standing out as relevant examples (Food and Agriculture Organization of the United Nations, 2014). Improving agriculture productivity is linked with poverty reduction and enhanced food security in countries such as Rwanda, Zambia, Guatemala, the Dominican Republic, Ghana, and Nepal, where the vast majority of population is involved in smallholding subsistence agriculture.

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Nepal is an agrarian country with more than 65% of its population engaged in agriculture (Ministry of Agricultural Development, 2015). Agriculture sector contributed 29.2% to the national gross domestic product in 2015/2016 (Central Bureau of Statistics, 2017). The average landholding per household is declining over the decades in Nepal. A recent national sample census of agriculture in 2011/2012 reported an average landholding of 0.68 hectares (ha) per household. This is a decline from 1.11 ha reported by the first national sample census of agriculture in 1961/1962 (Central Bureau of Statistics, 2014). The number of farming households sharply increased from 1.52 million to 3.72 million between this period, compared with the increase in the cultivated land from 1.69 million ha in 1961/1962 to 2.52 million ha in 2011/2012. This disproportionate increase in the number of farming households and cultivated land has contributed not only to declining average landholding but also increased number of smallholder farmers. Nearly 95% of farmers with land hold less than 2 ha (Central Bureau of Statistics, 2013). Thus, Nepalese agriculture is dominated by small farmers that constitute the majority of the country’s poor population (Joshi et al., 2010). The high concentration of population, specifically poor, in agriculture sector amid the limited land availability has resulted in low level of improved agricultural technology adoption. The agriculture sector in Nepal is thereby characterized by low productivity both in terms of labor and land (Ministry of Agricultural Development, 2016).

Despite being an agrarian country, Nepal relies heavily on agriculture imports to meet the national food demand. There is a significant increase in import of rice and fresh vegetables in recent years causing an acute trade deficit (Joshi et al., 2018). This is acknowledged as a critical condition for Nepalese agriculture (Ministry of Agricultural Development, 2016). Several plans/policies and programs/projects such as the Agricultural Perspective Plan; National Agriculture Policy; Agricultural Development Strategy; and Prime Minister Agriculture Modernization Project inter alia aimed to improve agricultural productivity thereby increasing the domestic agricultural production as well as tackling poverty and food insecurity. With a mere 25.1% of agricultural entities being commercialized in Nepal, promoting commercialization in agriculture remains the main focus for many agriculture related policies in Nepal (Ministry of Agricultural Development, 2016).

Vegetable production is recognized as a sector having high prospect for commercialization in Nepal due to its comparative advantage in export markets. The comparative advantage is offered by considerable geographical diversity in the country. Moreover, vegetable sub-sector is acknowledged to have a great significance in improving overall living standard of small farmers, including female farmers not only through increased income, but also through increased vegetable share in their diet (Acharya & Kafle, 2018; Ali, 2008; Food and Agriculture Organization of the United Nations, 2014; LTS International, 2017; Nwanze, 2011; Sibhatu & Qaim, 2017; Weinberger & Lumpkin, 2007). Furthermore, shorter growing cycle and relatively easy market availability make vegetable production a good choice to the small-scale farmers for commercialization. There are evidence of a positive association between vegetable commercialization and household welfare. The development economists consider vegetable commercialization as a crucial feature of the development process (Food and Agriculture Organization of the United Nations, 2017; LTS International, 2017; Muriithi & Matz, 2015; Nwanze, 2011; Sibhatu & Qaim, 2017). Vegetable production along with smaller livestock is prioritized as agricultural sub-sectors that benefit the poor.

Commercial vegetable farming, which refers to producing vegetables not only for own consumption but also to sell in the market thereby improve the livelihoods of smallholder farmers, remains the major intervention adopted by national and international governmental and non-governmental organizations (Shrestha & Karki, 2017; Winrock International, 2016). Intervention approaches of such organizations mainly comprise of training related to different aspects of vegetable productions such as improved production technology, nursery management, production management, pest management, and fertilizer/soil management (ADRA Nepal, 2019; FORWARD Nepal, 2018; International Fund for Agricultural Development, 2017; LTS International, 2017; Winrock International, 2017). Value chain development is also an important intervention adopted to promote commercialization. Value chain development includes facilitation for enhanced access to input and output markets and linking important stakeholders along with the post-harvest processing (ADRA Nepal, 2019; FORWARD Nepal, 2018; Gurung, Regmi, et al., 2016; International Fund for Agricultural Development, 2017; Shrestha & Karki, 2017; Winrock International, 2017). Cooperation among farmers by forming formal groups and enhancing democratic participation of members in such groups is also an intervention for promoting vegetable commercialization (ADRA Nepal, 2019; International Fund for Agricultural Development, 2017; Winrock International, 2017). Demonstration, hands-on training on climate-smart intervention, and enterprise development are some additional interventions for promoting commercial vegetable farming in order to improve the livelihoods of smallholder farmers in Nepal (Shrestha & Karki, 2017).

Despite this, the commercialization rate is still low in the vegetable sub-sector compared with livestock sub-sector specialized in milk and meat production (Ministry of
Agricultural Development, 2016). It is key to understand the barriers that need to be overcome thereby facilitate the vegetable growers to transform into commercial farmers. Such transformation will be significant for achieving economic growth and poverty reduction in developing countries like Nepal. Under these backdrops, this article aims to assess socio-economic characteristics of commercial vegetable growers and analyze the factors associated with the adoption of commercial vegetable farming among vegetable growers.

**Research Method**

**Data Source**

This study relies on data collected by Nepal Vegetable Crops Survey (NVCS) 2009–2010. This survey was conducted by Central Bureau of Statistics (CBS) with the assistance of Asian Development Bank realizing the importance of vegetable sub-sector in the country. This sub-sector has further significance in quarterly gross domestic production estimation (Central Bureau of Statistics, 2011). The survey was the first of its kind with its exclusive focus on agricultural households growing vegetables for data collection. National representativeness was assured by 5,400 sampled vegetable growers selected through the standard statistical procedure. Samples were selected following a three-stage stratified sampling procedure. At the first stage, 34 districts prominent in vegetable farming were selected from each of 11 survey domains; 10 wards, from each sample districts, were selected at the second stage; and 20 households growing vegetable crops in three survey domains (Mid-west Tarai, Far-west Hills and Far-west Tarai) and 15 households in the rest of the survey domains were sampled from each of selected wards at the third stage for this survey (Central Bureau of Statistics, 2011). The sampling procedure constructed 11 sampling domains considering three geographical and five administrative divisions of the country (Figure 1). Sampling domains comprise the whole Mountain as one domain, and Hills and Tarai in each of five development regions constructing 10 domains. Proportionate distribution of the total area of vegetable crops; wards with and without commercial vegetable farming; and households with different sizes of land area under vegetable farming were also considered in the sampling procedure. Detail explanation of the sampling procedures and national representativeness, as well as reliability and validity of the data, is available in Central Bureau of Statistics (2010, 2011). The data were collected between mid-November 2009 and mid-February 2010 in two phases with a reference period of 12 months preceding
the enumeration day. The use of fairly old data is a limitation of this study. However, the importance of nationally representative data, which are not generated on a periodical basis in the least developed countries like Nepal should not be overlooked.

**Literature Review**

Nepalese agriculture is characterized as subsistence agriculture with production mainly aimed at household consumption. Nearly 75% of agricultural entities in Nepal is subsistient (Ministry of Agricultural Development, 2016). Hence, any transformation of self-consumption-oriented production to market-oriented production can be regarded as commercialization. In other words, in this study, it is related to output side of production with increased marketed surplus, which can contribute to increased income and increased intake of vegetable by families themselves resulting in better nutrition (von Braun et al., 1994). Commercialization in agriculture can be seen as an important gateway out of poverty as it generates higher income, improves balanced nutrient intake, and deals effectively with a new environment marked by rising population, income, urbanization, and climate change. Hence, commercialization of agriculture is considered as a possible driver for development and economic growth in less developed countries (Murithi & Matz, 2015; Pingali, 2007; Schultz, 1964; Sibhatu & Qaim, 2017; von Braun et al., 1994).

Efficient transformation of traditional subsistence agriculture to market-oriented commercial agriculture should not be taken for granted (von Braun et al., 1994). Several factors affect the process of agricultural commercialization or the adoption of commercial vegetable farming. The technology adoption framework suggests that personal, technical, and business factors are important for adopting commercial farming (Figure 2). Besides, there are also other uncontrolled factors that affect the adoption (Mariyono, 2017).

Personal factors related to farmers are considered precursor factors having a significant effect on decision-making process of any farm households. Socioeconomic factors such as education, caste/ethnicity, gender, landholding, family size, and main income source *inter alia* constitute some of the important personal factors (Feder & Umali, 1993; Jensen et al., 2014; Mariyono, 2017; Nepal & Thapa, 2009; Raut et al., 2011). Decision on the adoption is often influenced by farmer’s knowledge and perceptions about how to practice scientific knowledge, which is largely defined by level of education (Schultz, 1964). Education has a higher tendency to influence the transformation in agriculture (Ghimire et al., 2015; Jensen et al., 2014; Mwangi & Kariuki, 2015). Caste/ethnicity plays a vital role in social formation in Nepal. The “upper” castes tend to be more engaged in agriculture including commercial farming, compared to “middle” and “lower caste” (Raut et al., 2011). The “lower caste” are historically deprived of basic capital such as land, education, and money needed to engage in commercial farming. Similarly, due to patriarchal nature of Nepali society where resources are mostly controlled by male members, male-headed households have a higher chance of adopting commercial farming (Ghimire et al., 2015; Raut et al., 2011). Limited access to information sources, education, and social exclusion hinder the likelihood of adopting new technology by women (Jensen et al., 2014). Land is the most important source of wealth in Nepal and is also regarded as an important means for social status and power (Regmi, 1999). Landholding is directly associated with amount of cash income the farmers can accrue in commercial vegetable farming and is also related to risk-bearing ability associated with the adoption (Feder & Umali, 1993; Jensen et al., 2014; Raut et al., 2011). Similarly, higher landholding provides the advantage of economy of scale. Hence, land is expected to have a positive significant contribution in agricultural transformation from subsistence to commercial farming (Ghimire et al., 2015; Mariyono, 2017; Raut et al., 2011). Family size can be seen as a proxy for labor availability on the farm. It can be expected that a household with larger family size has a capacity to relax any labor constraints while adopting commercial vegetable farming.

New technologies are the key factors to facilitate commercialization. Access to technical assistance and inputs such as chemical fertilizers, pesticides, irrigation, and improved seeds are some of the important technical factors that help farmers in adopting commercial farming. All these technical factors are important determinants of adopting commercial vegetable farming (Feder & Umali, 1993; Nepal & Thapa, 2009; Raut et al., 2011; von Braun et al., 1994). Business factors include access to loan, geographic region where the farmers are residing, and land property. Commercial vegetable farming is capital intensive requiring relatively huge investments. Access to loan is considered a critical business factor that facilitates agriculture transformation from subsistence to commercial farming by easing investment constraint faced by smallholder farmers. It is expected that farmers’ access to credit will contribute positively to the adoption of commercial farming (Feder & Umali, 1993;
Ghimire et al., 2015; Mariyono, 2017; Mwangi & Kariuki, 2015; Raut et al., 2011; Suvedi et al., 2017; von Braun et al., 1994) thereby increased income (Mohaid et al., 2021). Similarly, geographical location of the farm is an important factor affecting the adoption of commercial farming (Joshi et al., 2014). Location of farm in and around urban centers is the prime driver of agricultural commercialization (Nepal & Thapa, 2009). Geographical regions not only reflect market opportunities but also serve as a proxy of the level of infrastructure development. Besides, land properties such as number of land parcel owned, number of land parcel under vegetable farming, vegetable farming area, rented irrigated land, and irrigated area under vegetable farming are important variables associated with commercial vegetable farming. Population change and some macroeconomic policies, among others, are important factors which are factors beyond control in decision-making processes of farm households. Hence, residuals of such factors are beyond the scope of this analysis.

**Model Specification**

Commercialization can be measured in terms of the share of marketed produce to total produce produced within a given timeframe (von Braun et al., 1994). The NVCS 2009–2010 assumes the vegetable farmers to be commercial if they sell more than 50% of their produce (Central Bureau of Statistics, 2010). A direct question on the main purpose of vegetable farming is administered based on the cut-off (Central Bureau of Statistics, 2010). Thus, the dependent variable is a categorical variable with a binary response. This demands an application of a discrete choice model, more specifically a binary response model. This study employs probit model, which is the most widely applied model in adoption studies, especially when error terms are assumed to follow normal distribution (Chuchird et al., 2017; Feder & Umali, 1993; Ghimire et al., 2015; Ghimire & Huang, 2015; Jensen et al., 2014). Probit model investigates how the independent variables affect the probability of adopting commercial vegetable farming against not adopting it through an estimation of marginal effects of independent variables on the adoption. Probit model can be defined as follows:

\[
\Pr(Y_j \neq 0 | X_j) = \Phi(X_j \beta)
\]

where \( \Phi \) is the standard cumulative normal distribution, \( X_j \beta \) is the probit index (StataCorp, 2007) determined by the \( j^{th} \) observation of independent variables \( X \), and \( Y_j \) is the outcome variable of the \( j^{th} \) observation. Taking into consideration, the variables discussed under theoretical framework and the functional form defined in Equation 1, the probit model is specified as follows:

\[
Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_n X_{in} + \mu_i
\]

where \( Y_i \) is the adoption of commercial vegetable farming (1 if adopted and 0 otherwise); \( \beta_0 \) is the intercept; \( \beta_1 \) to \( \beta_n \) are the coefficients of the corresponding independent variables \( X_i \) to \( X_n \). Description of the independent variables, which are categorized broadly into three categories, is presented in Table 1.

STATA14 software is used to run the model. The software itself checks for some of the model specification problems such as multicollinearity and autocollinearity. However, efforts are also made to check those through a correlation matrix of all the variables considered in the model as well as variance inflation factor (VIF). Similarly, variables having possible endogeneity problems are dropped from the final model. This is done through the iterative process of model estimation.

**Results**

**Status of Vegetable Growers in Nepal**

Around 82% of plots under vegetable cultivation in Nepal is cultivated for household consumption. For this study, vegetable growers selling more than 50% of their produce are considered commercial vegetable growers and the rest as non-commercial vegetable growers or subsistence vegetable growers. Merely 15.2% of vegetable growers are considered commercial vegetable growers in Nepal. Moreover, only 4.3% vegetable growers perceive vegetable farming as their main source of income.

**Personal Factors**

Table 2 presents the differences in personal factors between commercial vegetable growers and subsistence vegetable growers. Only 15.2% of vegetable growers are engaged in commercial vegetable farming. The proportion of commercial vegetable farming is relatively higher among Tarai Bahun/Chhetri and Tarai Dalits. The proportion is the lowest in case of Hills/Mountain Dalit. Similarly, the proportion is higher among male headed vegetable growers. Family size, which also serves as a proxy for family labor supply, is higher among commercial vegetable growers. Education category shows a positive relation with the adoption of commercial vegetable farming. The proportion of commercial vegetable farming is the lowest for illiterate category and increases with the increase in education level. Landholding size of commercial vegetable growers is significantly higher compared to that of subsistence vegetable growers. The vegetable growers with vegetable farming as the main source of income have the highest rate of adoption, whereas those who are involved in salary/wages and trade/business have the lowest adoption rate of commercial vegetable farming. The proportion of commercial vegetable farming is the highest for vegetable growers who integrate

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their vegetable crops with other agricultural crops including livestock.

Technical Factors

Table 3 presents technical factors associated with commercial vegetable farming. Among the growers who do not have access to technical assistance, 90% of them are subsistence vegetable growers. Among commercial vegetable growers, more than 50% (417 out of 820) have access to technical assistance compared to around 22% (984 out of 4580) among subsistence vegetable growers. The difference in use of technical factor is even higher in case of chemical fertilizer. Close to 97% of the growers not using chemical fertilizer are subsistence vegetable growers (Table 3). It can also be translated as around 91% and 50% of commercial vegetable growers and subsistence vegetable growers, respectively, are using chemical fertilizers. The distribution is more or less similar in case of pesticide use. Irrigation availability is relatively better for commercial vegetable growers. The data

| Notation | Variables | Description | Variable type/definition |
|----------|-----------|-------------|--------------------------|
| Y        | Adoption  | Adoption of commercial vegetable farming by vegetable growers | Dummy: 1 if adopted, 0 otherwise |
|          | (Dependent variable) | | |
| **Personal factors** | | | |
| $X_1$    | Caste/ethnicity | Caste or ethnicity of the farm holder | Categorical variable (Dummy for different caste/ethnicity) |
| $X_2$    | Gender     | Gender of the farm holder | Dummy: 1 if male, 0 otherwise |
| $X_3$    | Family size | Family size in number | Continuous |
| $X_4$    | Education  | Education category of the farm holder | Categorical variable (Dummy for different education category) |
| $X_5$    | Landholding | Landholding size in hectare (ha) | Continuous |
| $X_6$    | Income source | Main source of income | Categorical variable (Dummy for different income sources) |
| $X_7$    | Land use   | Use of land for different crops | Categorical variable (Dummy for different land uses) |
| **Technical factors** | | | |
| $X_8$    | Technical assistance | Use of technical assistance | Dummy: 1 if used, 0 otherwise |
| $X_9$    | Chemical fertilizer use | Use of chemical fertilizer in vegetable production | Dummy: 1 if used, 0 otherwise |
| $X_{10}$ | Pesticide use | Use of pesticide in vegetable production | Dummy: 1 if used, 0 otherwise |
| $X_{11}$ | Irrigation availability | Availability of irrigation | Dummy: 1 if yes, 0 otherwise |
| $X_{12}$ | Availability of improved vegetable seeds | Easy availability of improved vegetable seeds as per the need | Dummy: 1 if yes, 0 otherwise |

| **Business factors** | | | |
| $X_{13}$ | Loan | Borrowing of the loan | Dummy: 1 if yes, 0 otherwise |
| $X_{14}$ | Rural/Urban | Location of farm in urban areas | Dummy: 1 if yes, 0 otherwise |
| $X_{15}$ | Ecological regions | Location of farm in different ecological regions | Categorical variable (Dummy for different ecological regions) |
| $X_{16}$ | Development regions | Location of farm in different development regions | Categorical variable (Dummy for different development regions) |
| $X_{17}$ | Survey domains | Location of farm in different survey domains | Categorical variable (Dummy for different survey domains) |
| $X_{18}$ | Land parcel | The number of land parcels owned by the farm | Continuous |
| $X_{19}$ | Vegetable land parcel | The number of land parcels under vegetable farming in the farm | Continuous |
| $X_{20}$ | Vegetable farming area | Land under vegetable farming (ha) | Continuous |
| $X_{21}$ | Rented irrigated land | Rented irrigated land under vegetable farming (ha) | Continuous |
| $X_{22}$ | Irrigated area | Irrigated area under vegetable farming (ha) | Continuous |

*There are 70 castes/ethnic groups reported by NVCS 2009–2010. These groups are broadly categorized into six castes/ethnic groups (Bennett et al., 2008), namely, Tarai Bahun/Chhetri, Hills/Mountain Bahun/Chhetri, Tarai Dalits, Hills/Mountain Dalit, Tarai Janajati, Hills/Mountain Janajati. |
suggest that 91.3% of the farmers not having access to irrigation are subsistence vegetable growers. The situation is slightly better in case of easy availability of improved vegetable seeds. Subsistence vegetable growers constitute 90.8% of vegetable growers without availability of improved vegetable seeds (Table 3). Improved vegetable seeds are

Table 2. Personal Characteristics of the Vegetable Growers.

| Variables                      | Commercial vegetable growers | Subsistence vegetable growers | Total      |
|--------------------------------|------------------------------|-------------------------------|------------|
| Caste/ethnicity ($\chi^2$ test p-value $- .00^{***}$) |                              |                               |            |
| Tarai Bahun/Chhetri            | 217 (34.0)                   | 421 (66.0)                    | 638 (100)  |
| Hills/Mountain Bahun/Chhetri   | 220 (11.0)                   | 1,789 (89.0)                  | 2,009 (100) |
| Tarai Dalit                    | 45 (25.6)                    | 131 (74.4)                    | 176 (100)  |
| Hills/Mountain Dalit           | 33 (8.4)                     | 362 (91.6)                    | 395 (100)  |
| Tarai Janajati                 | 112 (14.3)                   | 669 (85.7)                    | 781 (100)  |
| Hills/Mountain Janajati        | 193 (13.8)                   | 1,208 (86.2)                  | 1,401 (100) |
| Total                          | 820 (15.2)                   | 4,580 (84.8)                  | 5,400 (100) |
| Gender ($\chi^2$ test p-value $- .00^{***}$) |                              |                               |            |
| Male                           | 729 (15.8)                   | 3,875 (84.2)                  | 4,604 (100) |
| Female                         | 91 (11.4)                    | 705 (88.6)                    | 796 (100)  |
| Family size (t-test p-value $- .00^{***}$) | 6.6 ± 3.1                    | 6.2 ± 3.0                     | 3.2 ± 3.0  |
| Education ($\chi^2$ test p-value $- 0.12$) |                              |                               |            |
| Illiterate                     | 216 (13.5)                   | 1,379 (86.5)                  | 1,595 (100) |
| Primary education              | 315 (15.7)                   | 1,692 (84.3)                  | 2,007 (100) |
| Secondary education            | 268 (15.9)                   | 1,421 (84.1)                  | 1,689 (100) |
| College/professional education | 21 (19.3)                    | 88 (80.7)                     | 109 (100)  |
| Landholding (ha) (t-test p-value $- .00^{***}$) | 0.93 ± 0.99                  | 0.67 ± 0.84                   | 0.71 ± 0.87 |
| Income source ($\chi^2$ test p-value $- .00^{***}$) |                              |                               |            |
| Vegetable farming              | 227 (97.0)                   | 7 (3.0)                       | 234 (100)  |
| Other farming                  | 432 (12.6)                   | 3,007 (87.4)                  | 3,439 (100) |
| Salary/wages                   | 118 (9.0)                    | 1,191 (91.0)                  | 1,309 (100) |
| Trade/business                  | 43 (10.3)                    | 375 (89.7)                    | 418 (100)  |
| Land use ($\chi^2$ test p-value $- .00^{***}$) |                              |                               |            |
| Vegetable crops only           | 215 (14.4)                   | 1,274 (85.6)                  | 1,489 (100) |
| Mainly vegetable crops         | 468 (14.5)                   | 2,767 (85.5)                  | 3,235 (100) |
| Mainly other crops             | 137 (20.3)                   | 539 (79.7)                    | 676 (100)  |

Note. Figures in parentheses indicate percentage. ***Significant at 1% level of significance.

Table 3. Technical Characteristics of the Vegetable Growers.

| Variables                               | Commercial vegetable growers | Subsistence vegetable growers | Total      |
|-----------------------------------------|------------------------------|-------------------------------|------------|
| Technical assistance ($\chi^2$ test p-value $- .00^{***}$) |                              |                               |            |
| Yes                                     | 417 (29.8)                   | 984 (70.2)                    | 1,401 (100) |
| No                                      | 403 (10.1)                   | 3,596 (89.9)                  | 3,999 (100) |
| Chemical fertilizer use ($\chi^2$ test p-value $- .00^{***}$) |                              |                               |            |
| Yes                                     | 744 (24.7)                   | 2,272 (75.3)                  | 3,016 (100) |
| No                                      | 76 (3.2)                     | 2,308 (96.8)                  | 2,384 (100) |
| Pesticide use ($\chi^2$ test p-value $- .00^{***}$) |                              |                               |            |
| Yes                                     | 697 (29.4)                   | 1,671 (70.6)                  | 2,368 (100) |
| No                                      | 123 (4.1)                    | 2,909 (95.9)                  | 3,032 (100) |
| Irrigation availability ($\chi^2$ test p-value $- .00^{***}$) |                              |                               |            |
| Yes                                     | 655 (18.6)                   | 2,859 (81.4)                  | 3,514 (100) |
| No                                      | 165 (8.7)                    | 1,721 (91.3)                  | 1,886 (100) |
| Availability of improved vegetable seeds ($\chi^2$ test p-value $- .00^{***}$) |                              |                               |            |
| Yes                                     | 597 (20.0)                   | 2,388 (80.0)                  | 2,985 (100) |
| No                                      | 223 (9.2)                    | 2,192 (90.8)                  | 2,415 (100) |

Note. Figures in parentheses indicate percentage. ***Significant at 1% level of significance.
easily available to 72.8% (597 out of 820) of commercial vegetable growers compared to 52% (2388 out of 4580) for subsistence vegetable growers.

### Business Factors

Most of the smallholder farmers usually do not have enough capital to invest in relatively capital-intensive and external input-oriented agriculture like commercial vegetable farming. Acquiring loan is one of the important ways to ease this problem. The results suggest that among the vegetable growers having access to loan, 53% of them are commercial vegetable growers (Table 4). This also means 14.1% of commercial vegetable growers have access to loan compared to merely 2.2% of subsistence vegetable growers. The geographical variables reflect the prospects of commercial vegetable farming. Rural/urban divide, ecological regions, development regions, and survey domains are the geographical variables considered for this study. The results suggest that the proportion of vegetable growers involved in commercial vegetable farming is relatively higher in urban areas (18.9%) compared to that in rural areas (14.9%). In case of ecological region, the situation is better in Tarai where 17.7% of vegetable growers are commercial vegetable growers compared to 14.3% in Hills and 5.3% in Mountain. Central and Eastern development regions have higher proportion of vegetable growers involved in commercial vegetable farming compared to the other three regions. In case of survey domains, Eastern Tarai has the highest proportion of vegetable growers involved as commercial growers followed by

| Table 4. Business Factors Related to the Vegetable Growers. |
|-------------------------------------------------------------|
| Variables | Commercial vegetable growers | Subsistence vegetable growers | Total |
| Loan ($\chi^2$ test p-value $< 0.00000**$) | | | |
| Yes | 116 (53.0) | 103 (47.0) | 219 (100) |
| No | 704 (13.6) | 4,477 (86.4) | 5,181 (100) |
| Rural/Urban ($\chi^2$ test p-value $< 0.05**$) | | | |
| Rural | 754 (14.9) | 4,296 (85.1) | 5,050 (100) |
| Urban | 66 (18.9) | 284 (81.1) | 350 (100) |
| Ecological regions ($\chi^2$ test p-value $< 0.00000***$) | | | |
| Mountain | 24 (5.3) | 426 (94.7) | 450 (100) |
| Hills | 335 (14.3) | 2,015 (85.7) | 2,350 (100) |
| Tarai | 461 (17.7) | 2,139 (82.3) | 2,600 (100) |
| Development regions ($\chi^2$ test p-value $< 0.00000***$) | | | |
| Eastern | 268 (22.3) | 932 (77.7) | 1,200 (100) |
| Central | 336 (22.4) | 1,164 (77.6) | 1,500 (100) |
| Western | 91 (10.1) | 809 (89.9) | 900 (100) |
| Mid-western | 79 (9.3) | 771 (90.7) | 850 (100) |
| Far-western | 46 (4.8) | 904 (95.2) | 950 (100) |
| Survey domains ($\chi^2$ test p-value $< 0.00000***$) | | | |
| Eastern Hills | 93 (20.7) | 357 (79.3) | 450 (100) |
| Eastern Tarai | 162 (27.0) | 438 (73.0) | 600 (100) |
| Central Hills | 135 (22.5) | 465 (77.5) | 600 (100) |
| Central Tarai | 194 (25.9) | 556 (74.1) | 750 (100) |
| Western Hills | 38 (8.4) | 412 (91.6) | 450 (100) |
| Western Tarai | 53 (11.8) | 397 (88.2) | 450 (100) |
| Mid-western Hills | 52 (11.6) | 398 (88.4) | 450 (100) |
| Mid-western Tarai | 27 (6.8) | 373 (93.3) | 400 (100) |
| Far-western Hills | 17 (4.3) | 383 (95.8) | 400 (100) |
| Far-western Tarai | 25 (6.3) | 375 (93.8) | 400 (100) |
| Mountain | 24 (5.3) | 426 (94.7) | 450 (100) |
| Land parcel ($t$-test p-value $< 0.00000**$) | 3.6 $\pm$ 2.4 | 3.0 $\pm$ 2.0 | 3.1 $\pm$ 2.1 |
| Vegetable land parcel ($t$-test p-value $< 0.00000**$) | 1.7 $\pm$ 0.9 | 1.3 $\pm$ 0.6 | 1.3 $\pm$ 0.7 |
| Vegetable farming area ($t$-test p-value $< 0.00000**$) | 0.45 $\pm$ 0.52 | 0.24 $\pm$ 0.38 | 0.27 $\pm$ 0.41 |
| Rented irrigated land ($t$-test p-value $< 0.00000**$) | 0.39 $\pm$ 0.45 | 0.19 $\pm$ 0.29 | 0.27 $\pm$ 0.37 |
| Irrigated area under vegetable farming ($t$-test p-value $< 0.00000***$) | 0.32 $\pm$ 0.47 | 0.15 $\pm$ 0.33 | 0.17 $\pm$ 0.36 |

Note. Figures in parentheses indicate percentage.  
***Significant at 1% level of significance. **Significant at 5% level of significance.
Central Tarai, Central Hills, Eastern Hills, and Western Tarai. On the other hand, the proportion is the lowest in Far-western Hills (4.3%) followed by Mountain (5.3%).

The sampled 5,400 vegetable growers own 16,546 land parcels with the average number of 3.1 and size of 0.23 ha. The average number of land parcel is higher in case of commercial vegetable growers. Vegetable crops are grown in 7,224 land parcels. The average number of land parcel under vegetable farming is 1.3. The number is high (1.7 ± 0.9) in case of commercial vegetable growers compared to subsistence vegetable growers (1.3 ± 0.6). Ten percent of the commercial vegetable growers cultivate in irrigated rented land in contrast to only 3% in case of subsistence vegetable growers. The average size of irrigated rented land used for commercial vegetable farming is 0.39 ha. The vegetable farming area of commercial vegetable growers is almost double the size compared to that of subsistence vegetable growers, whereas irrigated vegetable farming area is more than double (Table 4).

### Probit Analysis

The final probit regression is adopted after the reiterative process starting with 50 independent variables, including dummies for the categorical variables. During the process, VIF is also estimated to avoid multicollinearity. The outcome of the adopted probit analysis is presented in Table 5. The model parameters suggest the final model is robust in

| Table 5. Marginal Effects of the Selected Variables on the Adoption of Commercial Vegetable Farming. |
|-------------------------------------------------|----------------|----------------|----------------|
| Variables                                        | Coefficient | SE             | Marginal effect | SE   | p-value |
| **Personal factors**                             |              |                |                |      |         |
| Caste/ethnicity (1 Tarai Bahun/Chhetri, 0 otherwise) | 0.46         | 0.09           | 0.084           | 0.02 | .000*** |
| Caste/ethnicity (1 Hills/Mountain Bahun/Chhetri, 0 otherwise) | −0.20        | 0.07           | −0.027          | 0.01 | .004*** |
| Caste/ethnicity (1 Tarai Dalit, 0 otherwise)     | 0.35         | 0.14           | 0.061           | 0.03 | .012**  |
| Gender (1 male, 0 otherwise)                     | 0.05         | 0.09           | 0.008           | 0.01 | .526    |
| Education category (1 illiterate, 0 otherwise)   | −0.05        | 0.06           | −0.007          | 0.01 | .403    |
| Land holding (ha)                                | −0.12        | 0.04           | −0.018          | 0.01 | .002*** |
| Income source (1 vegetable farming, 0 otherwise) | 2.69         | 0.21           | 0.812           | 0.04 | .000*** |
| Income source (1 salary/wage, 0 otherwise)      | −0.17        | 0.07           | −0.023          | 0.01 | .013**  |
| Land use (1 mainly vegetable crops, 0 otherwise) | 0.24         | 0.06           | 0.033           | 0.01 | .000*** |
| **Technical factors**                            |              |                |                |      |         |
| Technical assistance (1 yes, 0 otherwise)        | 0.51         | 0.06           | 0.087           | 0.01 | .000*** |
| Chemical fertilizer use (1 yes, 0 otherwise)     | 0.65         | 0.08           | 0.089           | 0.01 | .000*** |
| Pesticide use (1 yes, 0 otherwise)               | 0.73         | 0.07           | 0.112           | 0.01 | .000*** |
| Availability of improved vegetable seeds (1 yes, 0 otherwise) | 0.15         | 0.06           | 0.021           | 0.01 | .017**  |
| **Business factors**                             |              |                |                |      |         |
| Loan (1 yes, 0 otherwise)                        | 0.58         | 0.12           | 0.116           | 0.03 | .000*** |
| Rural/Urban (1 Urban, 0 otherwise)               | 0.12         | 0.11           | 0.018           | 0.02 | .282    |
| Ecological region (1 Mountain, 0 otherwise)      | −0.25        | 0.14           | −0.031          | 0.01 | .067*   |
| Ecological region (1 Tarai, 0 otherwise)         | 0.71         | 0.11           | 0.102           | 0.02 | .000*** |
| Development region (1 Eastern, 0 otherwise)      | 0.46         | 0.12           | 0.078           | 0.02 | .000*** |
| Development region (1 Central, 0 otherwise)      | 0.10         | 0.11           | 0.014           | 0.02 | .366    |
| Development region (1 Far-western, 0 otherwise)  | −0.29        | 0.14           | −0.047          | 0.03 | .036**  |
| Survey domain (1 Eastern Tarai, 0 otherwise)     | 0.45         | 0.15           | 0.081           | 0.03 | .003*** |
| Survey domain (1 Central Tarai, 0 otherwise)     | 0.49         | 0.15           | 0.090           | 0.03 | .001*** |
| Survey domain (1 Far-western Hills, 0 otherwise) | −0.33        | 0.21           | −0.038          | 0.02 | .122    |
| Land parcel                                      | 0.03         | 0.02           | 0.004           | 0.00 | .089*   |
| Vegetable land parcel                            | 0.22         | 0.04           | 0.032           | 0.01 | .000*** |
| Vegetable farming area                           | 0.48         | 0.08           | 0.068           | 0.01 | .000*** |
| Rented irrigated land (ha)                       | 0.40         | 0.23           | 0.057           | 0.03 | .078*   |
| Constant                                         | −2.94        | 0.15           |                 |      | .000*** |

**Note.***Significant at 1% level of significance. **Significant at 5% level of significance. *Significant at 10% level of significance.
explaining the association of commercial vegetable farming with the independent variables considered in the adopted model (Table 5). The average VIF of 1.56 with none of the variable exceeding a VIF of 2.76 indicates that multicollinearity is not an issue in the adopted model. Out of the seven variables associated with personal factors initially considered for estimation, family size is dropped considering its p-value close to one. Dropping family size from the model estimation did not affect the value of pseudo $R^2$. Besides, gender and education have no significance in the adoption of commercial vegetable farming in Nepal. Instead, Tarai Bahun/Chhetri have significant positive relation to adoption of commercial vegetable farming. Their probability to adopt commercial vegetable farming is 8.4% higher than other caste/ethnicity. Similar is the case for Tarai Dalit. In contrast, the association is negatively significant for Hills/Mountain Bahun/Chhetri signifying their probability to adopt the commercial vegetable production is 2.7% lesser. Land ownership shows negative significant association with adoption of commercial vegetable farming. A hectare increase in land ownership decreased the probability to adopt the commercial vegetable production by 1.8%. The significant association between the main source of income and adoption of commercial vegetable farming is as expected. Households with vegetable as the main source of income have positive significant association with the adoption. The probability of such households to adopt the commercial vegetable production is 81.2% higher. However, households with salary/wage as the main source of income have negative significant association with the adoption. In case of land use, it is found that those who are cultivating mixed crops (vegetable crops along with other crops) have significant association with adoption of commercial vegetable crops, instead of those who are cultivating vegetable crops only.

Among the technical factors, it is found that availability of irrigation in owned land is not relevant to the adoption. Besides, all remaining technical factors are crucial in the adoption. This is reflected by the positive significant coefficient for all technical factors, namely, use of technical assistance, chemical fertilizers, and pesticides; and availability of improved vegetable seeds (Table 5). Marginal effect is the highest for pesticides use (11.2%) followed by chemical fertilizer use (8.9%) and use of technical assistance (8.2%).

Access to loan increase the probability of the adoption by 11.6%. The probability of adopting commercial vegetable farming is higher in urban areas. However, the relation is not significant. The probability of adoption is significantly negative in Mountain (−3.1%), whereas it is positive (10.2%) and significant in Tarai. In case of development regions, vegetable growers in Eastern development region have positive (7.8%) significant association with adoption of commercial vegetable farming. In contrast, the probability is significantly negative (−4.7%) in Far-western development region. Eastern and Central Tarai survey domains have positive significant association with adoption of commercial vegetable farming, whereas is it negative in Far-western Hills. It is found that one unit increase in the number of land parcels owned as well as the number of land parcels under vegetable production increase the probability of adopting commercial vegetable farming by 0.4% and 3.2%, respectively. As expected, the area under vegetable farming has significant positive association with the adoption. Similarly, area of the irrigated rented land is also positive and significantly associated with adoption of commercial vegetable farming.

Discussion

Vegetable sub-sector is acknowledged to have great significance in improving food security of small farmers, including female farmers, not only through increased income, but also through increased vegetable consumption (Acharya & Kafle, 2018; Agricultural Projects Service Center & John Mellor Associates, 1995; Ali, 2008; Gurung, Thapa, et al., 2016; Pasa, 2017; Shrestha & Karki, 2017; Weinberger & Lumpkin, 2007). Vegetable farming is recognized as a sub-sector having high prospects of commercialization in order to enhance productivity in agriculture sector, thereby improving living standards of farm households (Agricultural Projects Service Center & John Mellor Associates, 1995; Ministry of Agricultural Development, 2016). Vegetables in Nepal are mainly grown for household consumption. More than three quarters of the produce are consumed domestically. This contributes to better dietary intake as diet in Nepal is relatively less diversified and dominated by carbohydrate (mainly rice). Commercialization rate of only around 15.2% indicates low level of vegetable commercialization in Nepal. Moreover, merely around 4% of vegetable growers perceive vegetable farming as their main source of income. This situation prevails despite vegetable farming being an important component of the development interventions to improve livelihoods of farm households (Agricultural Projects Service Center & John Mellor Associates, 1995; Gurung, Thapa, et al., 2016; Shrestha & Karki, 2017).

Probit analysis suggests that Tarai Bahun/Chhetri, who are considered better off in terms of their socio-economic status (Bennett et al., 2008) has significant positive relation with the adoption of commercial vegetable farming. Similar is the case in terms of Tarai Dalit, who are the most deprived and socially excluded section of the population in Nepal (Bennett et al., 2008). Many intervention programs targeting deprived caste/ethnic group (ADRA Nepal, 2019; FORWARD Nepal, 2018) including Tarai Dalit could be one important reason for this finding. Moreover, Tarai is the flat land of Nepal favorable for commercial farming. Whereas, the difficult terrain in Hills/Mountain could be the reason for negative significant association of the adoption with Hills/Mountain Bahun/Chhetri caste group. Land is associated with wealth, social status and power in Nepal (Regmi, 1999). The majority of large landholders are not engaged in farming. There is a common practice of renting
out their lands to smallholders (Pariyar et al., 2018; Sunam & Goutam, 2015). Besides, there is an acute shortage of agriculture labor in Nepal because of the significant youth outmigration for foreign employment (Piya & Joshi, 2016; Sunam & Goutam, 2015). This makes household labor crucial for agriculture. Thus, there is less tendency of engaging large landholders in commercial vegetable farming that is relatively labor intensive and relies mostly on household labor. Those households who consider vegetable farming as the main source of income are adopting it as a commercial venture. Whereas, household relying on salary and wage are not involved in commercial vegetable farming. In case of land use, households growing vegetable crops only, especially the small farmers practicing only the kitchen gardening, are less likely to adopt commercial vegetable crops. Instead, those who are involved in cultivating mixed crops are adopting commercial vegetable farming. Mixing crop is a prominent way to minimize farming risks in Nepal.

Irrigation is a crucial resource for any commercial agricultural production. Since renting-in land for vegetable farming is common in Nepal, irrigation availability in such land could be more important for adoption of commercial vegetable farming than the irrigation availability in own land. The owned land is used for different purposes but not necessarily vegetable farming. Education of the farm holder does not show significant relation to the adoption. However, technical assistance is crucial for promoting the adoption (ADRA Nepal, 2019; FORWARD Nepal, 2018; Winrock International, 2016), thereby increase income (Moahid et al., 2021). Similarly, access to chemical fertilizers, pesticides, and improved vegetable seeds are important for enhancing adoption of commercial vegetable farming among vegetable growers (ADRA Nepal, 2019; FORWARD Nepal, 2018; Gurung, Regmi, et al., 2016; Shrestha & Karki, 2017; Winrock International, 2017).

Access to loan is an important business factor associated with any capital-intensive venture, including commercial vegetable farming. It eases capital constraints faced by the farmers in accessing inputs such as improved seeds, chemical fertilizers, pesticides, and irrigation (Moahid et al., 2021). At the same time, there is high chance that the vegetable growers having access to loan will not be involved in commercial vegetable farming. The exponentially growing tendency of youth out-migration from the country (Piya & Joshi, 2016) could affect adoption of commercial vegetable farming. Loans borrowed are increasingly being used for financing the overseas migration, thereby resulting in more fallow lands. Since, this aspect is not covered by the survey, it is recommended to relate the access to loan with its use in future studies in order to draw a concrete conclusion in this regard.

The rural/urban divide is not so important in adopting commercial vegetable farming. With improved connection to market centers, the producers of rural areas in proximity of urban areas or even hinterlands are able to reach the market (Joshi et al., 2018). However, characterized by harsh climate as well as geography, the probability of adoption is significantly negative in Mountain, Far-western development region, and Far-western Hills survey domain. The situation is reverse in Tarai, where markets for input as well as output are relatively well developed and geography is quite favorable for commercial vegetable farming. The situation is similar in Eastern development region as well as Eastern and Central Tarai survey domains contributing to higher probability of adopting commercial vegetable farming. The higher number of land parcels is often associated with increased transaction cost, thereby being less competitive for commercial farming. However, relatively lower average parcel number and diverse characteristics of the land parcels might offer diverse opportunities for vegetable farming, thereby leading to the adoption of commercial vegetable farming. In addition, close proximity of the parcels with less impact on the transaction cost could have resulted in this finding. The area under vegetable production has significant positive association with the adoption, suggesting better return contributed by economy of scale. Irrigation is one of the crucial inputs for commercial vegetable farming. Hence, the area of irrigated rented land for vegetable farming plays a significant role in adoption of commercial vegetable farming. Thus, an initiative toward secure tenure agreements for irrigated land would be important in upscaling the vegetable commercialization as well as utilization of unutilized or underutilized land in Nepal (Jensen et al., 2014; Khanal, 2018).

**Conclusion**

Vegetable sub-sector within the agriculture sector has been identified as an important sub-sector in effectively dealing with the persistent problem of poverty and food insecurity in the least developed countries including Nepal. Hence, the sub-sector has been highly prioritized by government policies and remains as one of the important interventions in the plans and programs of government and national/international non-government organizations. However, commercialization rate in vegetable sub-sector is still low compared to the livestock sub-sector. The anticipated level of commercialization must be achieved to realize the overall development goal of poverty/food insecurity reduction, which remains one of the very important global goals including the sustainable development goals. One fundamental step in doing so is to understand the factors playing a decisive role in the adoption of commercial vegetable farming. With this emerging need, this article analyzes the personal factors of the vegetable growers, technical factors, and business factors responsible for the adoption.

Caste/ethnicity in the context of Nepal is a critical factor hindering adoption of commercial vegetable farming in Nepal. Equipped with better resources Tarai Bahun/Chhetri households are in a better position to adopt commercial vegetable farming. Caste/ethnicity in Nepal is also associated
with the hindrances in marketing of vegetable products as well as knowledge possession. Hence, awareness programs to facilitate marketing of the produces produced by socially disadvantaged caste/ethnic groups as well as targeting them in the interventions would be helpful in widening the prospects of vegetable commercialization in Nepal. Similarly, facilitation in the availability of, thereby accessibility to, technical factors, mainly technical assistance, chemical fertilizers, pesticides, and improved vegetable seeds will be essential in increasing the adoption of commercial vegetable farming. Since, rural-urban divide is not critical in defining commercial vegetable farming, intervention programs can be introduced in potential areas of the Hills and Tarai regardless of areas being rural or urban. This is more applicable in case of Eastern and Central Tarai. However, prospects of commercial vegetable farming in other regions should not be overlooked, especially in Western and Mid-western Hills. Land consolidation might not be important in the context that average number of parcels under vegetable farming is 1.7. Moreover, the number of parcels, which could have offered diverse opportunities, shows positive significant association with commercial vegetable farming. In the context of increasing tendency to leave land fallow mainly driven by youth out-migration in Nepal, any program or policies to facilitate secure land tenure would be vital in promoting vegetable commercialization. Similarly, provision of irrigation in the parcels where vegetable farming is taking place will be crucial in promoting commercialization. Hence, identification of such areas in the Nepalese context will be very important.

The analysis is based on descriptive statistics and probit model. Probit model estimates the association of the adoption with independent variables, but not causation. Rigorous empirical studies on causation employing updated data will help to understand the causes driving adoption. Similarly, consideration of geographical factors in terms of rural-urban continuum, that is, rural, peri-urban, and urban division, would be relatively important. Such demarcation reflects the access to output and input markets, which is among the most important factors driving the commercialization of vegetables.

Declaration of Conflicting Interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding
The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: TAOYAKA Program for creating a flexible, enduring, peaceful society, Organization of the Leading Graduate Education Program, Hiroshima University JSPS Grants-in-Aid for Scientific Research (B) (Overseas Academic Investigation) 15H05253 JSPS Grants-in-Aid for Scientific Research Young Researcher (B) 17K17917.

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