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ORIGINAL RESEARCH ARTICLE

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Factors influencing adoption of major orchard management practices in mandarin orange of Gorkha: A case from mid-hills of Nepal

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ABSTRACT

The mid-hills of Nepal have immense potential for mandarin orange production. However, its productivity is declining over the years despite an increasing trend in the cultivated area. Since the proper adoption of orchard management practices has been associated with increased productivity, it is, therefore, an imminent requirement to sustain the mandarin orange production for long in the country. Therefore, a research survey was carried out to assess the adoption of major orchard management practices and identify factors affecting its adoption so that the insights from this finding would provide potential policy implications for the rejuvenation of the declining orchards. Altogether, 93 households from Gandaki and Sahid Lakhan Rural municipalities, as well as Gorkha Municipality from Gorkha district were chosen for the study using a simple random sampling technique. Data were collected with a semi-structured interview which was analyzed using SPSS and Stata software. A seemingly unrelated regression (SUR) logit model was used for triangulating the effect of different variables on the adoption of major mandarin orange orchard management practices. The findings revealed that nearly two-third of the households reported citrus decline in their orchards. Further, the adoption of major orchard management practices was mostly found driven by regular access to extension agents, and the income generated from agriculture. Nevertheless, the adoption was plagued by the prevalence of citrus decline in the orchard. In light of these findings, participatory training programs related to the rejuvenation of declining orchards, regular advisory and extension services, and input subsidies to the smallholding farmers are suggested so that the adoption of major orchard management practices gets increased among the mandarin orange farmers.

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INTRODUCTION

In Nepal, Mandarin orange is a crop of comparative advantage since it is more rewarding than labor-intensive cereal crops in the present context of out-migration (Manandhar *et al.*, 2019). It is generally cultivated in the terraced land throughout mid-hills under the rainfed condition with the intercropping of cereals like maize and millet. Intercropping of these cereals requires heavy tilling that causes injury to the roots providing a congenial environment for the entrance of pathogens leading to severe

root rot. Root rot along with pest havoc such as citrus greening and fruit fly infestation has lead to a serious decline in the yield of Mandarin orange in Nepal (NCRP, 2017). To give an idea, the data from 2002/03 to 2017/18 shows that while the productive area of mandarin orange more than doubled during this period, the productivity (production per hectare), however, declined by 9.2 percentage (Figure 1). Although citrus greening was first discovered in Nepal in 1964 (Knorr *et al.*, 1970), it was found to be widely spread in the country by the nineties (Ghosh, 1993). However, even in the declining context mandarin orange

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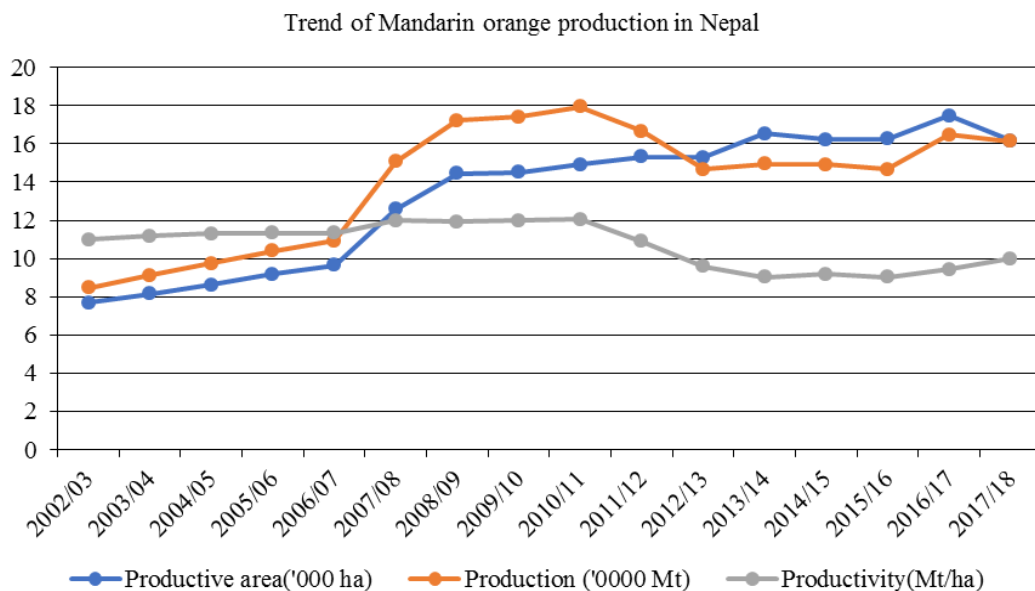
Figure 1. *Trends of mandarin orange production area, production, and productivity in Nepal Source: MoALD (2018).*

planted near home, animal shed, and compost pit that received better care were found to be more productive (Budathoki and Pradhanang, 1990). This is because Farmyard manure (FYM) is the major source of nutrient among the majority of the mandarin orange growers in Nepal (Joshi *et al.*, 1995), and is also directly correlated to soil fertility in the bench terrace cultivation system of mid-hills (Acharya *et al.*, 2007). Moreover, productivity is also found to be increased by the adoption of proper orchard management practices which include nutrient and pest management along with timely irrigation practices (Nabi *et al.*, 2012; Abbas and Fares, 2009; Dorji *et al.*, 2016; FAO, 2011).

Several studies have been conducted around the world considering the adoption of improved crop production technologies where a range of socio-economic, institutional, and technological factors have been found to be associated with adoption. However, there have been only a few studies in the case of Nepal. Moreover, much of the focus has been on cereal crops (Ghimire and Wen-Chi, 2015; Ghimire *et al.*, 2015; Subedi, *et al.*, 2019). The mandarin orange differs not only as a commodity but also differs in terms of the topography of cultivation. Further, the present state of decline in production is questioning its sustainability. Therefore, ensuring the adoption of major orchard management practices is imperative to increase the productivity of mandarin as well as to sustain mandarin orange cultivation for the long run. Hence, this paper aims to assess the level of adoption of major orchard management practices in the mandarin orange orchards located in the Mid-hills of Nepal and to find out the major factors affecting those adoption decisions so that the insights from this finding would provide potential policy implications for the rejuvenation of the declining orchards.

However, this study was concentrated only in one out of the major mandarin orange producing districts of the country because of the monetary and time constraint. And, it is possible that the mandarin orange orchards in different regions of the country varies in terms of severity of the decline. Therefore, due care must be given while generalizing the results obtained from this study.

MATERIALS AND METHODS

Study site and sample collection

The study was conducted in the Gorkha district (Figure 2) which lies in the Gandaki Province of Nepal. The site was selected purposively for three reasons. Firstly, it is the prominent region of mandarin orange production in the country. Secondly, realizing the potential of the district for mandarin orange production, the Prime Minister Agriculture Modernization Project (PMAMP) has declared the district as the Citrus Zone intending to increase the productivity of citrus along with its commercialization. And thirdly, the Citrus Zone has currently implemented the Citrus Orchard Rejuvenation Program, therefore the findings from this research will be beneficial in the effective implementation of that program. Further, three municipalities, namely Gorkha municipality, Sahidlakhan rural municipality, and Gandaki rural municipality were purposively selected because most of the mandarin orange producers in the district were located in these regions. Finally, a simple random sampling measure was used to collect the data from 93 mandarin orange-producing households. The primary data was collected through face-to-face interview using a semi-structured interview schedule. Also, the questionnaire was pre-tested before the final survey. The primary data covered socio-demographic information along with the information related to the adoption of major orchard management practices. Furthermore, two community-level Focus Group discussions (FGDs) were done to validate the collected information. The collected data was then analyzed using SPSS (version 23.0) and Stata (version 13.0).

Empirical framework of the study

In order to understand the determinants of adoption of major orchard management practices of Mandarin orange, namely application of Farm Yard Manure (FYM), fertilizer, micronutrient, timely irrigation, pruning, mulching, intercropping, and Bordeaux mixture application, a set of econometric models was specified and estimated using seemingly unrelated regression (SUR) logit.
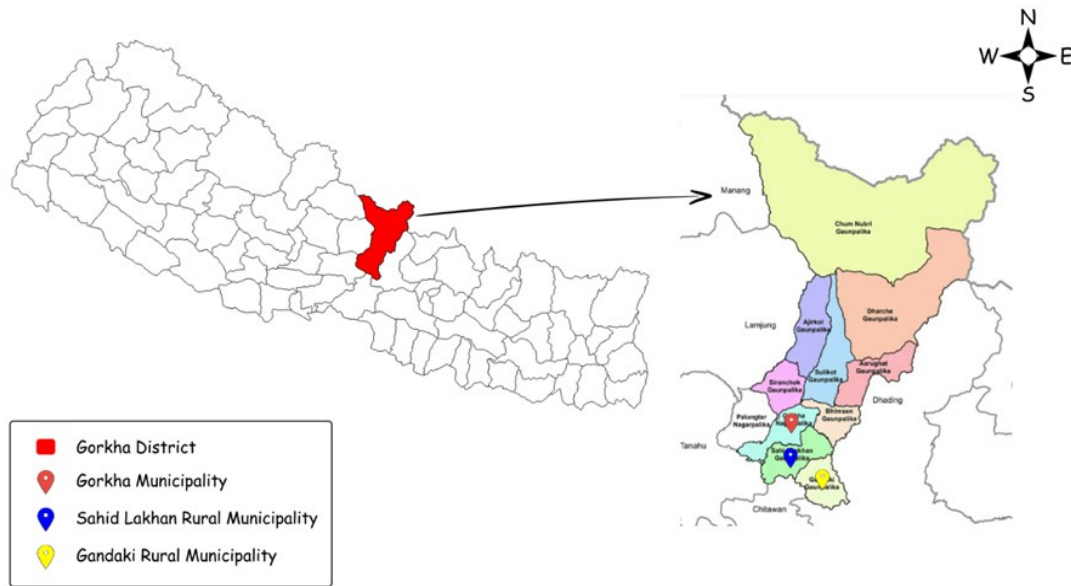
Figure 2. Map of the study sites showing the mandarin orange pocket areas.

The binary logit model is used to describe the relationship between the binary outcome variable and a set of independent or predictor variables (Hosmer *et al.*, 2013). In this study Seemingly Unrelated Regression (SUR) logit was used to better understand the important factors that affect the adoption decision of major orchard management practices of mandarin orange. The adoption decision is found to be influenced by the set of socio-economical, behavioral, institutional, and technical factors (Carrer *et al.*, 2017; Career *et al.*, 2019; Kattel *et al.*, 2020).

The dependent variables on the orchard management practices are binary and take the value $Y_j = 1$ (for the adoption) and $Y_j = 0$ (for otherwise); where (j=1,2......8) are the eight major orchard management practices devised for adoption by Prime Minister Agriculture Modernization Project (PMAMP), Citrus Zone office located in Gorkha. If X is the vector of explanatory variables that affects the farmers' decision on adoption, and if B is the vector of slope parameter that measures the change in probability of farmers decision on adoption with the single unit increment in X, then the probability of adopting the orchard management practices is given by (Gujarati, 2009).

$$Pi = E(Yi = 1|Xi) = \frac{1}{1+e^{-Z}} = \frac{e^Z}{1+e^Z}$$

Where,

$$Z = \beta_0 + \beta_1 X_{-i} + \varepsilon_i$$

Similarly, the probability of not adopting the major orchard management practices is given by

$$1 - Pi = \frac{1}{1+e^Z}$$

Therefore,

$$\frac{P_i}{1-P_i} = e^Z$$

Now, its logit transformation is given by,

$$Li = \ln\left[\frac{P_i}{1-P_i}\right] = Zi = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \varepsilon_i$$

Where,
Y_i = Adoption of major orchard management practices
X_i = Vector of explanatory variables that are included in the logit model; β_i = Parameters to be estimated; ε_i = Error term of the model; e = base of natural logarithm (ln); L_i = Logit

$\frac{P_i}{1-P_i}$ = odds ratio in favor of adopting the major orchard management practices

Here, the eight same explanatory variables define the adoption decision on the eight major orchard management practices. Therefore, the Seemingly Unrelated Regression (SUR) logit model was used to identify the factors associated with the adoption of eight major orchard management practices. This was done by using the functional form of the logit model expressed by Gujarati (2009) and Kattel *et al.* (2020).

$$Y^*_{ij} = \beta_0 + \beta_1. FC_{ij} + \beta_2. FA_{ij} + \beta_3. IF_{ij} + \beta_4. TC_{ij} + \upsilon_{ij}, (j = 1, 2, 3 ..., 8)$$
$$Y_i = \beta_0 + Age_{ij} + \beta_1. Yearschool_{ij} + \beta_2. Familytype_{ij} + \beta_3. LSU_{ij} + \beta_4. lnagriincome_{ij} + \beta_5. farmerscategory_{ij} + \beta_6. accext_{ij} + \beta_7. decline_{ij} + \varepsilon_{ij}$$

Where j= 1,2,3...8 denotes the major eight major orchard management practices. Here, β is a vector of slope parameters and FC is a farmers characteristic (Age, Years school, Family type), FA is farm assets (livestock holding in LSU, household income from agriculture, farmers category), IF is Institutional Factor (access to extension agent) and TC is Technological Constraints. (Table 1)

Variable specification

There exists a vast amount of literature on technology adoption. In general, technology adoption is found to be influenced by socio-economic, institutional, and technological factors. For this study, we have divided the factors likely to affect adoption decisions into four major categories; farmers' characteristics, farmers' assets, institutional factors, and technological constraints (Table 1).

Farmers' characteristics

Age, education, and family type are the explanatory variables under this category. With the increment in age, farmers also gain farming experience, capital, and better knowledge regarding the new technology. Therefore, age has been found to have a positive effect on adoption (Mignouna *et al.*, 2011; Ghimire and Wen-Chi, 2015). However, since young farmers are more innovative and have more likelihood to take the risk, there are also cases where they are found to be more likely to adopt new technologies (Asfaw *et al.*, 2012). Hence, the relation of adoption with age is indeterminate. It is also believed that education gives farmers' a better ability to perceive first-hand information, search for better opportunities and analyze the future outcome to solve their production problems (Uaiene, 2011; Ramirez, 2013; Ghimire and Wen-Chi, 2015). Therefore, the expected sign on the coefficient of education is positive. Joint family, in general, is large and provides a larger labor force for agriculture. So, if the household labor force is usually low, they might not adopt those technologies which are labor-intensive (Doss, 2006). Therefore, the expected sign on the coefficient of family type is positive (as joint family 1, nuclear 0).

Farmers' assets

Variables included under this category are livestock holdings in Livestock Standard Unit (LSU), agricultural income, and farmers' category. Since agriculture in mid-hills is characterized by Crop-livestock integration (Das and Shivakoti, 2006), livestock is considered as an asset that can either be used in the production process or exchanged for cash or another productive asset (Bekele and Drake, 2003). Therefore, the expected sign on the coefficient of LSU is positive. Since farmers are motivated to get involved in the production of crops effectively only when they realize optimum return (Abbas *et al.*, 2017), several studies have shown the income from agriculture to be positively associated with technology adoption (Carrer *et al.*, 2017; Career *et al.*, 2019; Kattel *et al.*, 2020). However, the pursuit of involvement in off-farm income-oriented activities often indicates lower farming efficiency (Goodwin and Mishra, 2004). Therefore, in this study, not the off-farm income but the annual household income from agriculture is taken as one of the factors for adoption. And the expected sign on the coefficient is positive. Agricultural production is found to be more efficient in large-sized holdings (Niroula and Thapa, 2007). Furthermore, farmers with larger landholdings are considered to be positively associated with adoption decisions as they can afford to cultivate on some part of their land with improved agriculture technology (Uaiene, 2011; Mariano *et al.*, 2012; Asfaw *et al.*, 2012). Thus, the

expected sign on the coefficient of semi-commercial and commercial farmers is positive.

Institutional factor

The Variable used under this category is access to extension agent. It is true that farmers get informed regarding the proper method of technology adoption and the resulting benefit from its use through extension agents (Mwangi and Kariuki, 2015). Based upon the innovation-diffusion theory, the access of farmers to information stimulates the drive for adoption (Uaiene, 2011). Empirical evidence has shown the positive relation of access to extension agents with technology adoption (Genius *et al.*, 2014). Thus, the expected sign on the coefficient of access to the extension agent is positive.

Technological constraints

The variable used under this category is the prevalence of citrus decline. Since the citrus decline is one of the major problems in Mandarin orange production in mid-hills (FAO, 2011), the continuous decline in production might have altered farmers' perception of the potentiality of improvement in mandarin orange productivity even after the adoption of orchard management practices is ensured. It is well known that risks and uncertainty associated with technology alter the adoption decision (Marra *et al.*, 2003). Therefore, the expected sign on the coefficient of the prevalence of citrus decline is negative.

RESULTS AND DISCUSSION

Descriptive analysis of variables used in the model

Table 2 shows the frequency of adoption of the eight major orchard management practices. Of the eight orchard management practices, the most adopted practice was pruning (82%), followed by application of FYM (65%), Bordeaux mixture application (59%), intercropping (58%), mulching (40%), micronutrient application (30%) and irrigation (27%). The least adopted measure on the other hand was chemical fertilizer application (14%). Table 3 shows the descriptive statistics of the explanatory variables used in the model. Under the farmer characteristics category, the average age of the household head was found to be 51.73 years and they had their formal education of about 6.26 years. Further, almost 41% of the households were found to live in a joint family. Similarly, in the case of farmers' assets, the average number of livestock holdings of the farmer was 8.93, and almost 33% of farmers were semi-commercial and commercial with a tree count greater than 200 in their orchards. Also, about 68% of the farmers had regular access to extension agents and nearly two-thirds of farmers were having citrus decline in their orchards.

Factors affecting the adoption of major orchard management practices

The adoption of orchard management practices might be influenced by farmers' characteristics, farmers' assets, institutional factors, and technological constraints as well. The SUR logit

Table 1. Description of variables used in the econometric analysis of the adoption of major orchard management practices of mandarin orange in the study area.

Variable	Description of variable	Expected sign
Dependent variable		
FYM	1, if the farmer practice application of recommended doses of FYM, 0 otherwise (Model 1)	
Fertilizer	1, if the farmer practice application of recommended doses of Chemical fertilizer, 0 otherwise (Model 2)	
Micronutrient	1, if the farmer practice regular use of micronutrient in the orchard, 0 otherwise (Model 3)	
Irrigation	1, if the farmers have access to year-round irrigation, 0 otherwise (Model 4)	
Pruning	1, if the farmer practice regular pruning in the orchard, 0 otherwise (Model 5)	
Mulching	1, if the farmer practices regular mulching in the orchard, 0 otherwise (Model 6)	
Intercrop	1, if farmer practices intercropping, 0 otherwise (Model 7)	
Bordeaux	1, if the farmer practices regular application of Bordeaux mixture, 0 otherwise (Model 8)	
Explanatory variables		
Farmers characteristics		
Age	Age of the household head (in years)	±
Year school	Formal education of the household head (in years)	+
Family type	Type of the family (1= joint family, 0 = nuclear family)	+
Farmers assets		
LSU	Livestock holding in Livestock Standard Unit (LSU)	+
Lnagriincome	Natural log of Annual household income from agriculture in NRs	+
Farmers category	Farmers category (1 = Semi-commercial and commercial farmers, 0 = small holders)	+
Institutional factor		
Accext	Access to extension agent (1= household have regular access to extension agent, 0 = otherwise)	+
Technological constraints		
Decline	Prevalence of decline in the orchard (1= decline is prevalent, 0 = otherwise)	-

Source: Own illustration based on field survey (2020).

Table 2. Frequency of adoption of proper orchard management practices of mandarin orange in the study area.

Orchard management Practices	Frequency of adoption (n=93)	Percentage
Pruning (yes=1)	76	82
FYM (yes=1)	60	65
Bordeaux mixture (yes=1)	55	59
Intercropping (yes=1)	54	58
Mulching (yes=1)	37	40
Micronutrient (yes=1)	28	30
Irrigation (yes=1)	25	27
Chemical fertilizer (yes=1)	13	14

Source: Field survey (2020).

model was used to analyze these factors and the summary of the findings is presented in Table 4. Prevalence of decline in the orchard, access to extension agent, and income from agriculture were the major factors that had a significant impact on the adoption decision of farmers. In particular, the prevalence of decline had a negative and significant impact on the adoption of FYM ($p<0.05$), micronutrient ($p<0.1$), mulching ($p<0.1$), and Bordeaux mixture application ($p<0.1$). This implies that the prevalence of decline insinuated the fear among the farmers regarding the orchard to be irreversibly damaged, and thus its inability to get rejuvenated even if the managerial practice is ensured. Since the risk and uncertainty associated with technology have been found to alter the adoption decision (Marra *et al.*, 2003), it might also be the case here. Further, as the rejuvenation of the orchard takes time even after the proper management is well ensured (Dorji *et al.*, 2016), the farmers in the study area were negligent in the adoption.

Despite this backdrop, access to extension agent was found to positively influence the adoption decision of FYM ($p<0.01$), fertilizer ($p<0.1$), micronutrient ($p<0.01$), irrigation ($p<0.01$), pruning ($p<0.05$), mulching ($p<0.05$) and Bordeaux mixture application ($p<0.01$). This finding is supported by the study from (Genius *et al.*, 2014). The positive influence of extension agents on adoption decisions is because of the fact that farmers get better informed not only about the proper method of technology adoption but also about the resulting benefits from its use from extension agents (Mwangi and Kariuki, 2015). Also, the income from agriculture had a positive and significant impact on the adoption decision of FYM ($p<0.01$), irrigation ($p<0.01$), mulching ($p<0.1$), and Bordeaux mixture ($p<0.1$). These managerial inputs incur a cost. For instance, water harvesting technique is the most practiced method of irrigation in mid-hills which requires the construction of tanks for water storage and the installation of pipes to channelize the water up to orchards.

Table 3. Descriptive statistics of the explanatory variables used in the econometric analysis.

Variables	Mean	Standard deviation
Age (in years)	51.73	11.17
Education (in year of schooling)	6.26	3.83
Family type (Joint =1)	0.41	0.49
Livestock holding (in LSU)	8.93	13.88
Income from agriculture (in natural log)	11.91	0.99
Farmers' category (Semi-commercial and commercial=1)	0.33	0.47
Access to extension service (yes=1)	0.68	0.47
Decline of mandarin orchard (yes=1)	0.66	0.48

Source: Field survey (2020).

Table 4. Results of the SUR logit model: Factors affecting adoption of proper orchard management practices by Mandarin orange farmers.

Variables	FYM	Fertilizer	Micronutrient	Irrigation	Pruning	Mulching	Intercrop	Bordeaux
				Yes=1				
age	-0.002	0.002	0.002	-0.003	0.002	-0.002	-0.002	0.009
	(0.007)	(0.003)	(0.006)	(0.005)	(0.002)	(0.007)	(0.007)	(0.007)
yearschool	0.000	-0.002	0.010	0.009	0.013*	-0.003	0.020	0.029
	(0.019)	(0.009)	(0.016)	(0.015)	(0.007)	(0.020)	(0.021)	(0.020)
familytype	0.064	0.114	0.086	0.174	0.009	-0.042	0.015	0.200
	(0.119)	(0.075)	(0.101)	(0.109)	(0.034)	(0.127)	(0.132)	(0.124)
lsu	-0.001	0.000	-0.006	-0.006	-0.001	0.004	0.033***	0.002
	(0.006)	(0.002)	(0.006)	(0.006)	(0.003)	(0.007)	(0.012)	(0.007)
lnagriincome	0.241***	0.019	0.082	0.176***	0.031	0.140*	-0.190**	0.135*
	(0.079)	(0.035)	(0.062)	(0.066)	(0.025)	(0.079)	(0.084)	(0.081)
farmercategory	0.123	0.037	0.258*	-0.064	0.064	0.066	-0.342**	0.097
	(0.146)	(0.077)	(0.156)	(0.091)	(0.048)	(0.162)	(0.165)	(0.159)
accext	0.420***	0.107*	0.362***	0.242***	0.231**	0.275**	-0.202	0.365***
	(0.127)	(0.054)	(0.081)	(0.078)	(0.110)	(0.111)	(0.123)	(0.125)
decline	-0.185**	-0.100	-0.222*	-0.036	-0.062	-0.231*	0.231*	-0.208*
	(0.104)	(0.075)	(0.119)	(0.090)	(0.039)	(0.124)	(0.130)	(0.117)
Summary statistics								
Number of obs.	93	93	93	93	93	93	93	93
LR ch^2(8)	41.15***	15.37*	44.11***	39.91***	41.26***	24.61***	33.46***	30.83***
Pseudo R^2	0.340	0.204	0.388	0.369	0.466	0.197	0.264	0.245

Notes: Figures in parenthesis indicate percentage. dy/dx (marginal effect after logit) is presented in table. ***($p<0.01$), **($p<0.05$), * ($p<0.1$).

Since the installation of this input incurs a cost on part of farmers, only those who have greater income from agriculture could afford it (Carrer *et al.*, 2017; Kattel *et al.*, 2020).

However, in the case of intercropping, income from agriculture had a negative and significant effect ($p<0.05$) whereas the prevalence of decline had a positive and significant effect ($p<0.1$). This is because the prevalence of decline led to the decrease in the amount of mandarin orange production and ultimately caused the reduction in farmers' income. Therefore, this promoted farmers to intercrop in their orchards in search of additional income. For instance, some of the farmers were found to cultivate mango, pomegranate, and banana as an alternative to mandarin orange. As we all know, all of the orchard management practices shown in Table 2 are beneficial to sustain mandarin orange production except for intercropping because intercrop not only competes with mandarin orange for nutrients but also, in some cases, promotes diseases. Extension agent on the other hand informed farmers about the harmful effect of intercropping. Therefore, although not found to be significant, the access of extension agent had a negative effect on intercropping. Also,

the semi-commercial and commercial nature of farming had a negative and significant impact on intercropping ($p<0.05$). One possible explanation for this is the fact that the investment for inputs in large farms is not proportionally high compared to its production. Further, they can spread the risk of failure by only allocating part of their land for trial on improved orchard management to observe their effectiveness (Mariano, 2012). Thus, seeing the good result of the trial they adopt the beneficial orchard management practices efficiently as well as effectively. Moreover, because they realize an optimum return from better management, they prevent themselves from adopting any of the measures that hinder their major crop production which in this case is intercropping. This finding is also consistent with the study from (Uaiene, 2011; Asfaw *et al.*, 2012). One contradictory result in the study is the positive and significant association of livestock holding with intercropping ($p<0.01$). Since agriculture in mid-hills is characterized by Crop-livestock integration (Das and Shivakoti, 2006), the intercropped maize is generally cultivated as fodder to feed livestock as a result farmers' with larger livestock holdings intercropped.

Conclusion

This study shows that the major factors affecting the adoption of major orchard management practices in mandarin orange were prevalence of decline, access to extension agent, and income from agriculture. Although the citrus decline in Nepal is not a new context, the problem at present is rampant than ever in the study area which has not only increased the likelihood of intercropping but has also led to crop diversification to other alternative crops in search of additional income. Thus, to sustain mandarin orange production it is suggested that a participatory training program related to the rejuvenation of the declining orchards has to be given the utmost priority in the citrus orchard rejuvenation program. Also, the training program on orchard management practices is suggested to be followed by regular advisory and extension services to give farmers the required initial thrust of motivation for adoption. Moreover, subsidies on inputs must be provided to the small holding farmers. This will result in its affordability as a result poor economic condition won't be a reason for not adopting orchard management practices in their case.

Declaration of competing interest

The authors declare no conflict of interest.

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