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## An Impact of Innovations on Agricultural Production and Malong the Koshi-Highway of Eastern Nepal

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### Abstract

*The study assesses the impact of using new technologies on crop production and marketing of selected crops particularly in the case of the Eastern hills. It also evaluates the role of governmental and non-governmental organizations to improve agricultural production systems too. Relevant data have been collected from both primary and secondary sources. Primary data draws from the interview, key informant survey and field observation. For this, 30 percent sample households were selected from three altitude belts (upper, middle and lower belts) ranging from 300 to 2,250 masl along the Koshi-highway. It has a wide range of climates, ranging from sub-tropical to alpine with monsoon precipitation in the summer for three and half months and therefore it has diversity in flora and fauna, and people. Similarly, secondary data have been gathered from various books, journals and official records. This paper presented that the crucial impact of acceptance of innovative methods in agriculture in the study area is a combined effort of both local people and government. The government together with the development agencies and non-government organizations has contributed to impart knowledge of the agriculture innovative methods in the local farmers and at the same time, the farmers were enthusiastic to learn and adopt those methods. As a result, one can easily see the remarkable changes in crop production due to the impact of new technologies.*

**Key Words:** adoption, germination test, treatment, seeds, yielding

### Introduction

Agricultural innovation indicates the use of new techniques and technologies in agricultural sector to achieve better output. In Nepalese context, various new techniques have been using to increase quality and quantity of crops both. Chemical

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fertilizers, high yielding varieties of seeds (HYVS), plant protection measures (PPM) and Seed germination test/seed treatment (SGT/ST) have been widely adopting for a long time in the eastern hills (Wagle, 2019). Agrawal et.al (1978) found the use of chemical fertilizer is highly interrelated with the distance from the road and availability of extension service centers in the Gandaki zone of Nepal. In addition, farmers' perceptions, infrastructure and the economic incentives of the agriculture sector are also equally important to decide alternative production techniques. It can be argued that those farmers who adopt farm inputs have certainly changed their products to get good prices from the market. But, it requires too much time to watch-and-see from their neighbors, to advice continuously, and to increase their understanding about the new technologies. It is mainly due to most of the resource constraints farmers largely unable to use their land, labor and capital in better way in many developing countries (Berner, Harrison, Baxter, 1984).

In the same perspective, Virgo and Subba, 1994; Khatiwada, 2014 revealed the case of hills and they found that there are some changes occurred in the agriculture sector along the Koshi Highway. They indicated that high valued commercial crops have replaced to cereal-based subsistence farming. They also point out that the establishment of the then Pakharibas Agriculture Research Centre (PAC), increasing access to roads, farmers' self-efforts and market integration, and GO and NGOs supports are drivers to change. Some studies related with innovations diffusion have been done in the case of the eastern hills however, the impact of using such technologies especially on cropping pattern and crop production has not seen yet in detail (Wagle 2019). In this context, this paper attempts to adress this issue in detail.

## **Method and Materials**

### **Sources of Data**

The paper is based on both primary and secondary data. Primary were collected from field observation, interview, focus group discussion, questionnaire and key informant survey conducted in 2016. Secondary data were gathered through various books, journals and official records. In addition, collected data were tabulated as required. Simple statistical tools percentage and percentile change were used. On the basis of analyzing gathered data, a descriptive paper was prepared. Both quantitative and qualitative techniques have been used in order to achieve the goal.

### **Selection of Sample Sample study Centers and Households**

The specific study area was delineated along the buffering of 1.50 km of the Koshi Highway of Dhankuta district based on **central place theory of Walter** Christellar where rapid changes in agriculture sector have occurred after the decade of 1980. It was divided in three ecological belts on the basis of agro-climatic classification of the then

District Agriculture Development Office Dhankuta. At least 3 study centers were taken as representative from the each belts randomly. Chitre, Sindhuwa and Jorpati centers from upper altitude; Kuwapani, Kagate and Dhankuta Bazar from middle altitude and Guthitar, Rudrabari and Mulght from lower altitude belt were selected respectively. The study was based on stratified random sampling method. For this purpose, almost 30 percent (166 households) farm households were selected from three ecological belts having more than 0.50 hectare (0.83 ropani) both *Khet* and *Bari* land.

**Table 1:** Method of Sampling Households (In Households)

Altitude Belts	Total Households	Distance from Koshi Highway In meters			Sample Households	Mean Farm Size (In hectares)
		0-500	501-1000	1001-1500		
Lower	101	10	10	10	30	0.78
Middle	265	28	28	24	80	1.10
Upper	185	19	19	18	56	1.01
<b>Total</b>	<b>551</b>	<b>57</b>	<b>57</b>	<b>52</b>	<b>166</b>	<b>1.02</b>

Source: Field Survey, 2016

Moreover, Chemical fertilizer, high yielding variety of seeds, plant protection measures and seed germination test were included as modern innovations in the study. The farmers who have adopted all innovations were considered as an 'Adopter'. Similarly, who had used more than one innovations were categorized under the 'Partial Adopters' whereas other groups fall in the category of 'Non-adopters' in the study.

### Study Area

The southern slope of the eastern hills is flourishing different from the other parts of Nepal in various ways, such as geographical, ecological, historical, socio-cultural and economic perspectives (HMG/MoE, 1974). The farming population of this area is also living in subsistence agricultural system. It is a region of great natural and social diversity, resulting from the tremendous geographical and climatic extremes. In this area, altitudes (300-2250masl) and climates are ranging from sub-tropical to alpine and long periods of winter dryness altering with torrential downpours during the monsoon. This is a challenging for human survival. It is mainly due to poor resource base, especially, cultivated land; the extreme terrain and climate mean that communications are often poor and infrastructure minimal. The great majority of the people who live in this region are subsistent farmers. Over the centuries these people have developed strategies for survival that can be maintained independent of contact with the adjacent regions. Indeed, such conditions are found in the Hindu-Kush Himalayan Region (Ya & Tulachan, 2003). Majority of farmers living in this area seem to have gradually changed their socio-economic conditions after the adoption of new technologies in their agricultural works. Koshi Hill Area Rural Development

Project (KHARDEP) is one of the Integrated Rural Development Program (IRDP) approach launched in the eastern hills of Nepal. KHARDEP has made Koshi Highway. It has been able to transfer technology through advanced seed production (Improved seeds), farmer training, exposure visits and field demonstration. In addition, the contribution of District Agriculture Development Office (DADO, Dhankuta), the then National Orange Research Center (NORC, Dhankuta) and non-governmental Organizations also seems very important. With all these efforts, the Koshi Highway seems to have brought major changes in the agricultural development of this area since the mid 1980s. In the study area, Koshi highway provides access to the supply of chemical fertilizer, the high yielding variety of seeds and plant protection measures at a significant rate. Indeed, it was comparatively low in the past (Pathak 2010). The use of chemical fertilizer, improved seeds and pesticides is increasing in the study area especially for high-value cash crops and off-season vegetable farming. But the amount of use of agricultural inputs is decreasing with the increasing distance from the road (Khatiwada, 2014). This situation is relevant to not only in the eastern hills, but also equal to other regions of Nepal and in many other parts of developing countries (Wagle, 2019). Thus, it is relevant to the rigorous study about the result of using these technologies and changing attitudes of the farmers towards the selection of crops for their agricultural works.

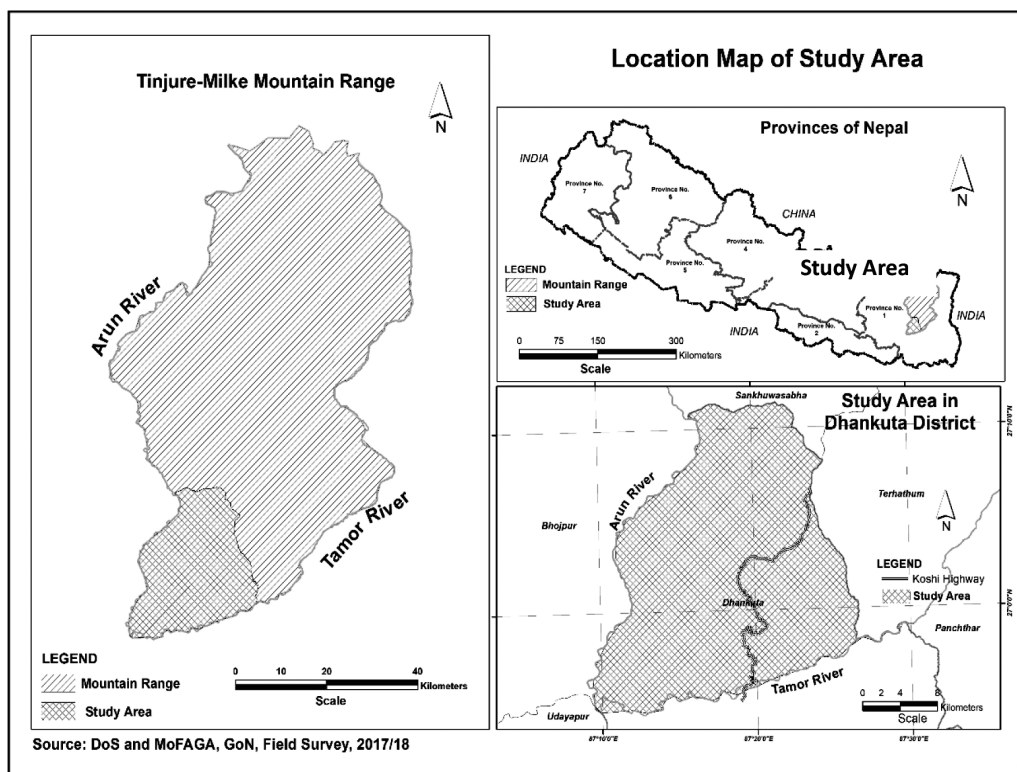
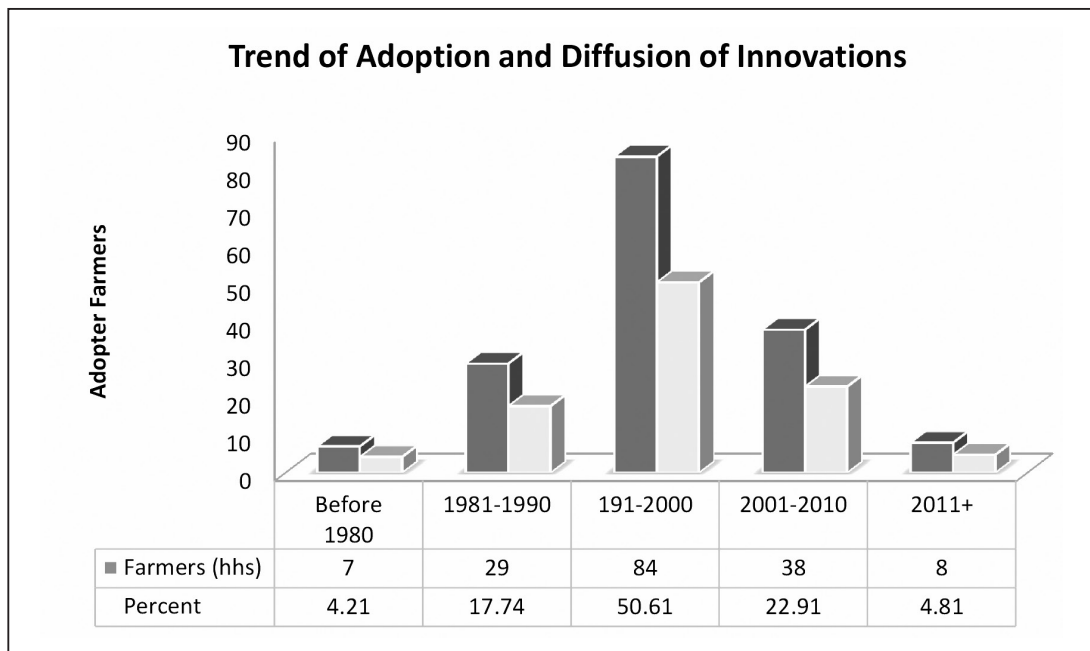


Figure 1: Location Map of the Study Area

## Discussion and Results

The local elite intellectuals and farmers stated that the foundation of modern agriculture was created from 1960 to 1990 in the eastern hills. Some important innovations diffusion friendly policies and programs implemented by the then government seem to be the milestone to develop this sector. The extension of Agricultural Service Centers, construction of the Koshi Highway, subsidy in agricultural inputs and implementation of integrated Rural Development Programs (IRDP) were considerable achievements at that time in the area. In addition, the contribution of the then Pakharibas Agriculture Centre (PAC, 1978) and Koshi Hill Area Development Program (KHARDEP, 1977) as non-governmental organizations also seems remarkable to promote the agricultural sector of this area at that duration. After that, joint efforts of both governmental agencies and non-governmental agencies have been playing significant role to develop the agriculture sector of the study area after the restoration of democracy in 1990 (Figure 2).



Source: Field Survey, 2016

**Figure 2:** Adoption and Diffusion of Agricultural Innovations in the Study Area (In Households)

The figure indicates that only 4.21 percent (7 households) farmers have used agricultural innovations at the beginning. It was started from the Kagate and Dhankuta centers of the middle altitude at first and it is taken as the first beginning point towards the adoption in the eastern hills (Wagle 2019). The figure shows that the adoption

reaches in the climax during the years of 1991 to 2000. Almost, 51 percent (84 households) farmers have adopted such innovations at that duration. The adoption and diffusion seems rapid in the beginning, and reaches at the top level by 2000. After that, diffusion faced rapid decrement trend. The existing trend indicates that the acceptance of innovations seems satisfactory but the sustainability of such new technologies is questionable (Wagle 2019). Besides the table also indicates that all farmers of the study area had user of any type innovations for their agricultural works in the past but some farmers had stopped to use such measures after some time.

### **Role of Organization to Promote New Technology**

Different GOs and NGOs have been working to promote the farming system of this area from a long time. These agencies are mainly focusing on cash crops. The key key informants have remarked that, District Agricultural Development (DADO, Dhankuta), Agricultural Research Station Pakharibas (ARSP) and National Citrus Research Programs (NCRP, Dhankuta) have a leading role to develop the agricultural sector of this area (Table 2). They have also mentioned that District Agricultural Development Office has been encouraging the farmers from a long time to use new technologies in the agricultural sectors as well as supporting technically and economically among the organizations. They are getting support from this agency especially on receiving improved seeds, irrigation and advice during the time of epidemics of plants diseases. Besides, they have been keeping contact for help and advice during the time of need. Along with this, this agency is actively involving to implement the current policies of government related to the agricultural sector of this area.

Beside this, Agriculture Research Station Pakharibas (ARSP) has been involving devotedly to impart new knowledge and technology in agriculture sector of this area since 1972. It was established by the then British Government to provide technical knowledge for Ex-Gurkhas soldiers to make them self-dependent. In the beginning, the organization supported the Ex-Gurkhas in their agricultural works. After that, gradually other farmers of the study area have also been benefitting through the programs of this organization. Recently, the organization is using 88.64 hectares land for the research purpose of developing new technologies related to the agricultural sectors. Now, the organization is being popular among the farmers through its activities. The farmers have said that there is a leading role of this organization to bring the agricultural sector of eastern hills up to the present condition. This organization has been mainly involved in the research works. Apart from this, it has also been conducting seminars and training related to this sector (Table 2).

**Table 2:** Role and Involvement of the Organizations to promote Agriculture

Agencies	Number	Study Centers									Total Farmers (hhs)
		Chitre	Sindhuwa	Jorpati	Kuwapani	Kagate	Bazar	Guthitar	Rudrabari	Mulghat	
ARSP	Number	8	2	2	0	0	0	0	0	1	13
	Percent	4.80	1.20	1.20	0	0	0	0	0	0.60	7.80
DADO	Number	1	9	6	4	1	9	4	6	4	44
	Percent	0.60	5.40	3.60	2.40	0.60	5.40	2.40	3.60	2.40	26.50
ARSP + DADO	Number	1	8	2	18	10	13	6	6	2	66
	Percent	0.60	4.80	1.20	10.80	6	7.80	3.60	3.60	1.20	39.80
Ag. Centre	Number	1	4	2	0	0	0	0	0	0	7
	Percent	0.60	2.40	1.20	0	0	0	0	0	0	4.20
ARSP + Ag. Centre	Number	0	5	1	1	0	0	0	0	0	7
	Percent	0	3.0	0.60	0.60	0	0	0	0	0	4.20
NCRCP + ARSP	Number	0	0	0	1	14	7	0	0	0	22
	Percent	0	0	0	0.60	8.40	2.40	0	0	0	13.30
Others	Number	1	1	2	1	1	1	0	0	0	7
	Percent	0.60	0.60	1.20	0.60	0	0.60	0	0	0	4.20
Total	Number	12	29	15	25	26	29	10	12	8	166
	Percent	7.20	17.50	9.0	15.10	15.70	17.50	6	7.20	4.80	100

Source: Field Survey, 2016

National Citrus Research Programs (NCRP, Dhankuta) is the third leading organization which has been working for agricultural development. It was established in 1961 in mid- hilly region of Nepal with the purpose of developing and extending the horticulture in this region. In the beginning, it focused on the development and extension of both vegetable and fruit farming but now it focuses only in the development and extension of horticulture. The different species of fruits developed by this center are not only spreading in Nepal but spreading all over the world (Table 2). In addition, the remarkable role of Uttarpani Technical School can be seen to diffuse technical knowledge among the poor farmers by producing JT and JTAs. Apart from the three major governmental agencies, some other non-governmental organizations are also found helpful in the development of agricultural sector. Among these organizations named Society of Local Volunteers (SOLVE) and Poverty Alleviation and Rural Development Project (PARDEP) have also given contribution for the marketing of agricultural product.

The active involvement of governmental and non-governmental organizations has been playing vital role in the development of agricultural sector. Table 2 clearly shows that around 8 percent farmers (13 households) have got direct technological support from Agriculture Research Station Pakharibas for their agricultural works. Similarly, almost 27 percent (44hhs) farmers are benefiting from the technical and economic support of District Agricultural Development. Around 4 percent (7 households) farmers have got single support from agriculture extension centers.

In addition, farmers of the study area are getting regular support from more than one organization. The table also indicates that around 40 percent (66 households) farmers have been benefiting from regular technical and economic support of both organizations Agriculture Research Station Pakharibas and District Agricultural Development Office, Dhankuta. Likewise, almost 13 percent (22 households) farmers are receiving continuous support from National Citrus Research Programs, Dhankuta and Agriculture Research Station Pakharibas both. Besides, Agriculture Research Station Pakharibas and Agriculture extension centers are providing their joint services to almost 4 percent (7 households) farmers. In this way, more than 4.20 percent (7 households) farmers are getting support from other non-governmental agencies. In this way, the indispensable role of both GOs and NGOs has been promoting the agricultural works of this area.

### Impact of Innovations on Production of the Crops

**Vegetables and Fruits Production:** The production of crops depends on scientific use of the innovations. The balance use of these innovations helps to increase productivity of the crops otherwise the use of such innovations may change in to curse instead of boon (Wagle, 2019). In the present context, nearly 92 percent (152 households) farmers are involved in commercial vegetable farming from the total number. However, almost 85 percent (130 households) vegetable farmers have been using all innovations included in the study. If it is assumed 130 farmers as adopters, nearly 17 percent (22 households) seem as partial adopters among them. The income variation between is illustrated in the table (Table 3). The table exhibits that the adopter farmers are able to earn more than 11 percent (Rs 20,550) net income per hectare in comparison with the partial adopters per year. Generally, it seems that the adopter farmers are more sincere towards the proper adoption of innovations than partial adopters. The field survey data (2016) exhibits that exactly, 90 percent (117 households) adopter farmers have been using such technologies in proper time as compared to around 55 percent (12 households) of the partial adopter.

**Table 3:** Achievement from the Vegetables and Fruits Farming in 2015 (In 000 rupees per hectare)

Altitude Belts	Gross Income		Net Income	
	Adopters	Partial Adopters	Adopters	Partial Adopters
Upper Altitude Belt	350	275	250	200
Middle Altitude Belt	216.67	196.67	158.30	150
Lower Altitude Belt	266.67	225	200	196.67
<b>Total</b>	<b>277.78</b>	<b>232.22</b>	<b>202.77</b>	<b>182.22</b>

Source: Field survey, 2016



**Maize production:** The field survey figures show that 150 farmers have involved in maize cultivation by using around 47 hectare land of the study area. Around, 87 percent (130hhs) farmers are adopters, almost 9 are partial adopters and nearly 5 percent (7 households) are non-adopters among them. The present situation of maize production in the study area is given in table (Table 4).

**Table 4:** Maize Production of the Study Area in 2015, (Per hectare in kg)

Altitude Belts	Adopters	Partial Adopters	Non-adopters
Upper Altitude Belt	0	1650	0
Middle Altitude Belt	2265	2043.33	1546.67
Lower Altitude Belt	2253.33	0	1600
<b>Total</b>	<b>2259.16</b>	<b>1945</b>	<b>1565</b>

Source: Field survey, 2016.

The analysis of the table 4 concludes that the adopter farmers have achieved the highest productivity among the total maize growers. The statistical figures indicate that they have produced 2259 kg per hectare cultivated land which is relatively 16 percent (314.16 kg) higher than the partial adopters and around 44 percent (694.16kg) higher than the non-adopter farmers respectively. The similar study of Pathak (2010) also supports this result. He had found higher productivity of maize among the adopter farmers than the non-adopters in the case of Dhading district.

**Paddy production:** Limited land area exists cultivable for paddy production in the study area because of its nature. It needs sufficient irrigation, more labor and comparatively flatland. However, it has been being cultivated by making terrace in the hilly and sloppy area. The field survey figure indicates that only 2.88 percent (8.69 hectare) land of the study area has been being used for this purpose which is known as '*Khet*'. Approximately, 92 percent (7.99 hectare) paddy cultivating land is situated in the middle altitude and only around 8 percent (0.70 hectare) land is located in the lower altitude. Beside this, only 8.43 percent (14 households) farmers have grown this crop among the total farmers. And almost 71 percent (10hhs) is being used only one innovation i.e. chemical fertilizer among them. In addition, only partial adopter farmers have been involving in the paddy farming (Table 5).

**Table 5:** Paddy Production of the Study Area, in 2015, (Per hectare in Kg)

Altitude Belts	Partial Adopters	Non-adopters
Middle Altitude Belt	2759.33	0
Lower Altitude Belt	2910	2260
<b>Total</b>	<b>2797</b>	<b>2260</b>

Source: Field survey, 2016

Table 5 shows the difference of paddy productivity between the partial adopter and non-adopter farmers. The figure indicates that the productivity achieved by the partial adopters is almost 24 percent (537 kg) higher than the non-adopter farmers. The study made by Pathak (2010) also supports this outcome. He had identified higher productivity among the adopter farmers than the non-adopters in Dhading district.

The dissscussion refers that the impact of innovations is positive both on the selection and production of crops. Now, the choice of farmers seems towards the high valued, productive and profitable crops. As a result, the cropping pattern of the study area is gradually changed and moving towards the high valued cash crops farming.

### **Impact of Innovations on Marketing of Crops**

The major economic activities of some identified market centers of this area like Chitre, Sindhuwa, Jorpati, Kuwapani Guthitar and Rudrabari are based on vegetable production, collection and their marketing. In addition to this, some other small market centers have also developed for the same purpose in the same sloppy terrace field. Extension of urbanization and centers further playing significant role to diffuse such technologies in remote area also (Wagle, 2019). The visible contribution of innovations diffusion can be seen not only in the urbanization of this area it can be seen in the development of new market centers too. Apart from, several agricultural roads have played remarkable role to extend the market of local products and the supply of local needs through the connection with main highway. These roads have made possible to export large volume of local farm products from the study area to the warm southern Tarai consumption centers within the country, as well as to the towns and cities of neighbouring countries - India Bangladesh and Bhutan, where there is high demand of such mountain products, particularly the vegetables. The extension of such road networks seems possible through the positive result of such technologies on crops production and diversification which helps the farmers to generate additional income. In addition, the head of local vegetable cooperatives has informed that the high valued crops have their own distinct identity which makes easy to promote their market itself. Based on the comprehensive analysis of the study, the major findings related to the core objectives are listed in the following points:

- The trend of using new technologies is found slow in the beginning, rapid in middle and declining. Only 4.21 percent (7 households) farmers were adopters of innovations at the beginning period of before 1980. Exactly, 50 percent (65 households) were added during the period of 1991-2000 and reached 92 households as total adopters. Now 78.30 percent (130hhs) farmers have used new technologies for their agricultural works.

- The farmers have forwarded their steps towards commercial farming. Similarly, the role of GOs and NGOs seems useful for the adoption and diffusion process of innovations. The contribution of Agriculture Research Station Pakhribas and District Agriculture Development Office Dhankuta seems significant among the involving organizations.
- The land use and cropping pattern of the study area is gradually changed and moving towards the cash crops farming. The remarkable change has occurred in both land use and crop production in the study area from 1980 to 2016. The impact of using new technology seems useful in all crops production. The adopter farmers are able to earn more than 11 percent (Rs 20,550) net income per hectare in comparison with the partial adopters in vegetable and fruit production. Similarly, the productivity of adopter farmers in maize farming is seen relatively 16 percent (314.16 kg) higher than the partial adopters and nearly 44 percent (694.16kg) higher than the non-adopters respectively. Likewise, the productivity of partial adopters seems almost 24 percent (537 kg) higher than the non-adopter farmers in paddy production.

## **Conclusion**

The use of modern agricultural innovations can give good outcome at the beginnings but its result may not be useful and well in the short period. The main reasons of not successful outcome of such innovations are the unscientific use of the technology due to the lack of knowledge and poverty. Due to these reasons, decreasing soil fertility and the diseases in the crops are increasing day by day. As a result the durability and acceptance of the new technology can be questionable. If we use the technology properly, it is contextual and familiar. Effective monitoring system should be developed from both government and public sectors to make adoption of innovations environmental and crop production friendly.

Besides, the adoption and diffusion of innovation is also complex and dynamic process. This study has analyzed the trend of innovations diffusion and their impact on the cropping pattern and crop production, especially in the case of south slope of eastern hills. The southern slope of eastern hilly socio-economic environment is changing rapidly through the dynamics of adaptive techniques. Change has also occurred in attitudes and activities of people after overcoming the traditional thinking due to the increasing awareness. Therefore one of the striking conclusions of the present study regarding adoption of innovations is the fact that Koshi highway networks link to major urban centers of eastern Nepal as well as Indian markets have accelerated to the growth and development of offseason vegetables. In this change, the farmers

have pressured to adopt new technologies in the study area. Moreover, the impact of innovations is positive on the selection, production and marketing of selected crops. The cropping pattern of the study area is moving towards the high valued cash crops farming. Similarly, one can easily see the popularity of innovations everywhere of the study area due to their positive impact on production. The extension of market is also elaborated due to the universal identity of high valued crops.

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