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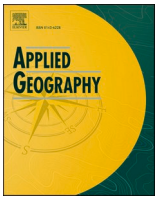

Understanding rural outmigration and agricultural land use change in the Gandaki Basin, Nepal

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ABSTRACT

This study investigates agricultural land use change in Chitwan, Nuwakot and Lamjung districts of Nepal during 1990 –2017 in relation to rural outmigration. Agriculture in Nepal is characterized by subsistence farming, low productivity, limited access to markets, constraints of terrain, poor economic returns, and vulnerability to natural hazards now exacerbated by climate change. These challenging circumstances are further compounded by several physical, environmental and socioeconomic challenges, including from labour outmigration. Outmigration has steadily increased over the past two decades, and a remittance economy has fuelled urbanization processes as well as transformations in the rural economy. Data was collected from three selected districts, representing two different agro-ecological zones - the mountains and plains (Terai). We use an interdisciplinary approach integrating macro scale and longitudinal geospatial analysis with quantitative econometric causal analysis and participatory qualitative methods. Results show that agricultural land abandonment is higher in mountain areas than in the Terai. The effect of outmigration on agricultural land abandonment also has an important gender dimension: internal outmigration of women has a significant positive effect on agricultural land abandonment. This shows that when men outmigrate, women continue farming leading to feminization of agriculture, but when women migrate in significant numbers, there are only older parents left who are often unable to continue farming. Similarly, and contrary to the general narrative and previous studies, international migration (of both men and women) did not show any significant impact on agricultural land abandonment.

1. Introduction

Agricultural land abandonment has become a global phenomenon as a consequence of changing priorities in economic development, a widening gap between agricultural and non-agricultural incomes, climate change vulnerabilities, and a gradual decrease in the rural workforce engaged in agricultural production (Hussain et al., 2016; Liu et al., 2014; MacDonald et al., 2000; Okahashi, 1996; Pointereau et al., 2008; Prishchepov et al., 2013; Queiroz et al., 2014; Rigg et al., 2017; Riggs, 2006; Shirai et al., 2017; Shui et al., 2019). Since the 20th century, around 3.8–4.7 million km^2 of cropland have been abandoned worldwide (Campbell et al., 2008) in an era when around 800 million people in the world are undernourished (FAO et al., 2018). Food security is still a critical global challenge (FAO et al., 2018) and sustainable land use is a key component to achieving sustainable development (Visockiene et al., 2019; Liu et al., 2018; Rey Filho et al., 2016).

Nepal is no exception when it comes to these trends. Agricultural land abandonment has emerged as one of the most critical challenges to agriculture and food security (Hussain et al., 2016; Paudel et al., 2016). In most parts of the country, with the exception of parts of the southern Gangetic plains (Terai) - agriculture is characterized by low productivity, subsistence farming, limited access to markets, high climate vulnerability, constraints of terrain, and high costs of food production and transportation (Hussain et al., 2016). Low agricultural productivity coupled with small landholdings means that farming alone is an insufficient source of livelihood for rural households (Paudel et al., 2014), particularly to meet the increased costs of health, education, and other services. In response, farm communities are diversifying their livelihoods by exploring non-agricultural income opportunities such as labour migration, small business, wage employment, tourism, and

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collection of medicinal and aromatic plants (Gioli et al., 2019; Siddiqui et al., 2019). Labour migration has become an important source of alternative and supplementary income (Maharjan et al., 2018). In Nepal, both internal and international labour migration have steadily increased over the past two decades. Internal migration patterns reveal that mostly, people are migrating from the hills and mountains to the plains. The last population census reported a negative population growth rate in 36 out of the 55 hill and mountain districts of the country (CBS, 2012). In the fiscal year 2015–16, remittances from international migrants were equivalent to about 30% of the country's Gross Domestic Product (GDP) (MOF, 2017). The percentage of remittance-receiving households has increased from 23% in 1995–96 to 56% in 2010–11 (CBS, 2011).

Although labour migration makes significant contributions to Nepal's national and local economy in the form of remittances, the narrative of international migration as a pathway out of rural poverty has been challenged in important ways. International labour migration and remittances have profound effects on agrarian and rural livelihoods, for instance by inflating land prices and decreasing the capacity of the poor to access land (Sunam & McCarthy, 2016), Labour migration may also induce negative impacts on local agriculture and food self-sufficiency. Studies from different parts of Nepal have revealed that labour migration is resulting in frequent labour shortages in agriculture leading to agricultural land abandonment and low productivity (Hussain et al. 2016, 2018; Khanal, 2002; Paudel et al., 2014; Thapa, 2001).

There is also an important gender dimension to be considered here. Women have historically played an important role in agriculture. The division of labour has traditionally been highly gendered, with men taking up work such as ploughing, irrigation, fertilization and carrying farm produce while women contributed more to planting, hoeing, weeding and harvesting. However, with increased outmigration of men, the gendered work division is often blurring with women taking care of most of the activities. Many studies have discussed the feminization of the agricultural sector in Nepal (Adhikari & Hobley, 2011; Gartaula et al., 2010; Jaquet et al., 2015; Maharjan et al., 2012; Paudel et al., 2012) with contrasting outcomes. Overall, few studies have looked into the gendered impact of migration on agricultural land abandonment. Migration is still a men-dominated phenomenon, however there is a gradual increase in the number of migrant women (Gioli et al., 2017), and the impact of women migration on agrarian transition is yet to be understood.

Finally, previous studies analysing migration and agricultural land abandonment seldom consider the differential effects of internal and international migration. In addition to migration, there are several other factors that lead to agricultural land abandonment (Ojha et al., 2017; Pointereau et al., 2008; Terres et al. 2013, 2015). In the context of the study areas, climate change (i.e. changes in temperature and precipitation patterns), physical constraints (slope, aspect and topography) and socioeconomic change (i.e. increasing education levels and growing population density) are the most critical factors. It is important to consider these factors in the analysis to capture their effect on agricultural land abandonment.

This study contributes to the growing literature on land and labour migration a number of ways. Firstly, it uses a multidisciplinary approach that includes geospatial tools, econometric techniques, and participatory methods to analyse land use change at the district level, using data from reliable official sources.

Compared to more widespread farm-level studies, a district-level interdisciplinary analysis provides information at a scale that is more relevant to decision makers and planners. The methodology used is simple enough to be easily replicable in other districts and even outside Nepal. Secondly, the study takes into account the differences between mountain and Terai areas in terms of agricultural land use change by including 'ecological zone' as an explanatory variable in the econometric analysis. Thirdly, this is one of few attempts at investigating the differential impacts of internal and international migration on agricultural land use change, including its gendered impacts. Lastly, despite the focus on migration dynamics, this study does not ignore other key socioeconomic, physical, and climatic drivers of agricultural land use change, and considers the most important ones as 'control variables' in the econometric model.

2. Land abandonment and migration

The narrative on labour migration as a pathway out of poverty is theoretically grounded in the new economics of labour migration (NELM), which argues that migration decisions are made by households to maximize expected income and minimize the risks (Stark, 1991). Overall, this theory fits well in the context of Nepal and other Hindu Kush Himalayan countries (Benz, 2016; Siddiqui et al., 2019), where the people, particularly from fragile hill and mountain areas, migrate to other areas to improve their income prospects, diversify their livelihoods, and mitigate the risks associated with it (Yang & Choi, 2007). Remittance contributes significantly to the national and local economy. However, outmigration also has negative impacts on agriculture as it frequently leads to labour shortages in critical stages of farm activities (Hussain et al. 2016, 2018; Khanal, 2002; Paudel et al., 2014; Thapa, 2001). Labour shortages and other socioeconomic changes caused by outmigration of farm labour are an important socioeconomic driver of agricultural land abandonment (Xu, Deng, Huang, et al., 2019; Rey Benayas et al., 2007; Strijker, 2005; Zhang et al., 2014; Aide & Grau, 2004; Anne & Martha, 2007; Lieskovský et al., 2015). However, comprehensive theories explaining the relationship between labour migration and agricultural land abandonment are still lacking, and few studies have statistically tested the relationship of labour migration and land abandonment using reliable quantitative data (e.g. Xu, Deng, Huang, et al., 2019; 2019b).

Existing literature shows that the spatial distribution of agricultural land abandonment within a country is uneven. For instance, agro-ecological facets are important and agricultural land abandonment is concentrated in the mountain areas of Central, Eastern and Mediterranean Europe (Alcantara, 2013; Estel et al., 2015; Hatna & Bakker, 2011; MacDonald et al., 2005; Weissteiner et al., 2011). Overall, outmigration is adversely affecting agricultural production across the Himalayas and the mountain areas of China, India, Nepal and Pakistan (Hussain et al. 2016, 2018; Rasul et al., 2014; Shi et al., 2018; Xu, Deng, Huang, et al., 2019).

In Nepal, there is a dearth of data on the extent of agricultural land abandonment at the sub-national and national scales. Recent micro level studies attributed abandonment of agricultural land to outmigration from rural areas. Hussain et al. (2016) reported that 26% of farm households in the Koshi River basin faced frequent labour shortages during critical periods of agricultural activity due to outmigration of active household members, particularly the youth. In the Sikles area of the Gandaki River basin, Khanal and Watanabe (2006) reported the abandonment of almost 30% of agricultural land. Labour shortage owing to outmigration is reported across the country, especially in the hills and mountains, where agriculture has remained highly labour-intensive with limited mechanization options. Consistently, the literature shows that spatial characteristic play an important role with respect to agricultural land abandonment. The literature also highlights unsuitable environmental conditions (Rey Benayas et al., 2007), low farm productivity (Rudel & Fu, 1996; Lieskovský et al., 2015) and unfavourable agricultural policy (Di;az et al., 2011; Prishchepov et al., 2013; Müller et al., 2009; Renwick et al., 2013) as drivers of land under-utilization. Climate change-induced extreme events, such as flash floods and drought, have also increased the risks and uncertainties associated with farm production (Beniston, 2003; IPCC, 2013, 2014; Jodha, 1992; Messerli et al., 2004), and led to land abandonment (Hussain et al., 2016). Physical factors, such as aspect and slope, also play an important role in agricultural performance and competitiveness. Villages located in steep mountainous terrain and remote locations are not only vulnerable to landslides and erosion that affect crops and irrigation systems, but

also lack access to markets (Merrey et al., 2018). In addition, increased household income also increases the tendency of people to migrate internally from rural areas to towns and urban centres (Paudel et al., 2014; Tacoli & Mabala, 2010) for better access to health, education and market facilities (Childs et al., 2014). Ojha et al. (2017) used the framework of 'socio-environmental pathways' to explain the land underutilization phenomena in Nepal, that consist of social, economic and policy dimensions. They demonstrate how behind land underutilization lie complex, cross-scalar processes, involving the interaction among social forces and environmental factors (Ojha et al., 2017, p. 158).

Based on this knowledge, we establish the general hypothesis that outmigration is likely to influence agricultural land abandonment but the influence may differ across gender and migration type. While testing the hypothesis, the regression analysis also considered other important climatic, socioeconomic and physical factors to control their effect (avoiding any omitted variable bias).

3. Material and methods

3.1. Study area

We conducted this study in selected sites of the Nepal part of the Gandaki River basin (hereafter basin), a transboundary river shared by China, Nepal, and India. About 19 percent of the Nepal's population lives in this basin, covering 19 districts and spanning from the Terai to the hilly and mountainous regions. The climate across the basin varies widely, with mean annual temperature ranging from −9.0 °C to 42.50 °C and rainfall from 27 mm to 2,500 mm. Both temperature and rainfall are lower in the mountains and higher in the Terai. About 66% of the population in the basin depend on agriculture as their main source of livelihood (CBS, 2011). Crop loss and declining production because of erratic weather conditions is a significant issue in the basin (Biggs et al., 2013; Chaudhary et al., 2012; Gentle & Maraseni, 2012; Manandhar et al., 2011; Regmi & Paudyal, 2009).

Based on the share in geographical area of the country, we randomly selected one district from the Terai (Chitwan), and two districts from the hilly (Nuwakot) and mountain (Lamjung) regions (see Fig. 1). Chitwan has a mean altitude of 385 masl, while Nuwakot and Lamjung districts have mean altitudes of 1,500 and 2,270 masl, respectively (see Fig. 1).

These three districts differ significantly in terms of socioeconomic and agricultural development (see Table 1). Chitwan performs best on the Human Development Index, Human Poverty Index, and district labour productivity, followed by Lamjung and then Nuwakot.

The Terai lies in the Gangetic plains and experiences favourable climatic conditions for crop production, particularly for two major cereal crops, paddy and maize. It is also known as the grain basket of the country. Use of agricultural inputs, area under irrigation and mechanization are higher in the Terai than in the hills and mountains due to its favourable topography (FBC, 2006). Not only is the area under irrigation higher in Chitwan than it is in Lamjung and Nuwakot, the sources of irrigation are also more diverse (such as dam/reservoir, tube well/-borewell). As a result, Chitwan enjoys higher yields for both paddy and maize than Nuwakot and Lamjung (see Fig. 2).

The migration situation in the selected districts and for Gandaki basin overall is presented in Table 2. The Census 2011 reported a total absentee population (international) of 1.9 million in Nepal, and the basin accounts for 31% of it.

International migration is highest in Chitwan district and internal migration in Nuwakot district. Chitwan also shows a higher proportion of women migrants than the other two districts. Whereas the major international destinations for men migrating are countries in South East Asia and the Middle East followed by India, for women migrants these

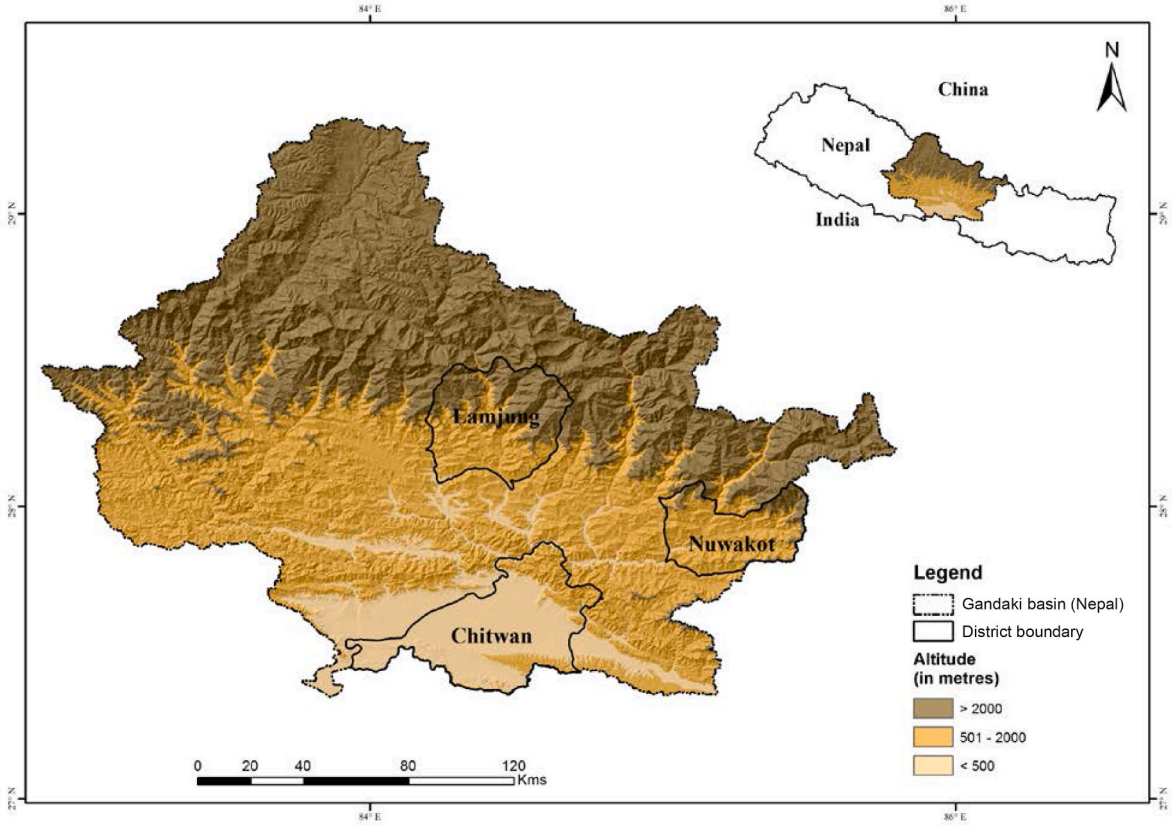

Fig. 1. Gandaki basin showing the study districts.

Table 1
Socioeconomic and agricultural development indicators for the three selected districts.

District	Socioeconomic development			Agricultural development*			
	Human Development Index (2011)	Human Poverty Index (2011)	District labour productivity rank (2011)	Area under irrigation (%)	% of holdings reporting the use of implements		
					Power tiller	Tractor	Thresher
Chitwan	0.551	24.8	7	76	2	72	60
Lamjung	0.507	26.98	29	51	0.1	0	0
Nuwakot	0.466	35.66	37	42	2	0	1

Source: NPC and UNDP 2014; *CBS, 2012.

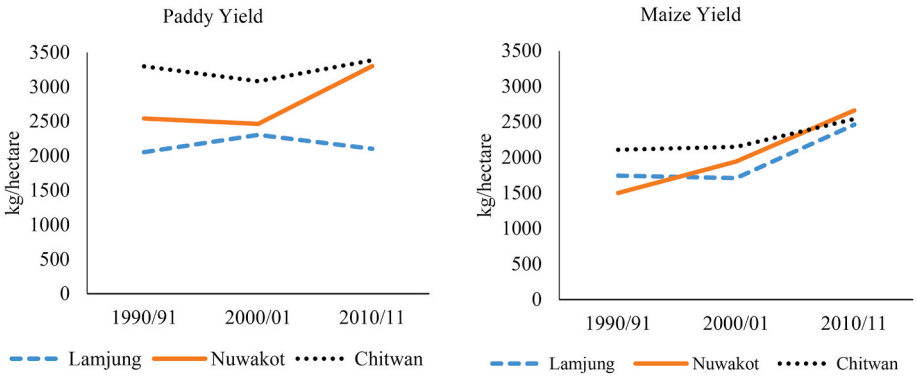

Fig. 2. Yield of paddy and maize in the study districts.
Source: Ghimire, 2014.

Table 2
Internal and international migration situation in the Gandaki basin and selected districts in 2011.

Migration		Chitwan		Nuwakot		Lamjung	
		Male	Female	Male	Female	Male	Female
International migration (number of persons)		43,728 (15)	6693 (23)	12,466 (9)	1844 (1)	19,242 (26)	1918 (2)
Destinations of international migrants (% of total absentee population)	India	21	22	21	33	24	43
	South East Asia and the Middle East	59	28	69	46	67	23
	Europe, USA, Canada, Pacific Ocean (including Australia)	13	39	4	13	4	23
	Others	7	11	6	8	5	11
Internal migration (number of persons)		18,819 (6)	10,488 (36)	25,910 (20)	18,769 (13)	16,640 (22)	12,491 (14)

Note: Figures in parentheses: Male – % of total male population; Female – % of total female population.
(Source: CBS, 2011).

destinations differ across the study districts (as reported in Table 2).

3.2. Interdisciplinary methods: Rationale and design

Previous studies on agricultural land use change and its determining factors in Nepal either used a macro approach based on district level or national level data (Paudel et al., 2016) or a micro approach based on household surveys (Jaquet et al., 2015; Khanal & Watanabe, 2006). This study investigates agricultural land use change and empirically tests the effects of migration on these changes at the meso scale – VDC level. It also examines the differentiated effects of various types of migration and the gendered impacts of migration on agricultural land use change. It has adopted a multi-disciplinary approach integrating macroscale longitudinal geospatial analysis with qualitative methods (key informant interviews and focus group discussions conducted in 2017) and quantitative econometric analysis.

For the econometric analysis, as the only data source available that is representative at VDC is the census 2011, this study analyses the changes in agricultural land use during the period 1990 and 2010, using the census 2011 data. Such longitudinal approach helps in better understanding agricultural land use change in the context of population and environmental change (Milan et al., 2015). The primary data collected via qualitative methods is used to validate the relevance of the findings of the quantitative analysis in the period 2010–2017, and provides an in-depth views on local perceptions of the issues under study.

3.3. Agricultural land use changes using geospatial tools

We analysed the trends in agricultural land use change for the three selected districts using the LULC dataset developed by the International Centre for Integrated Mountain Development (ICIMOD) for 1990 and 2010 (Uddin et al., 2015). The LULC datasets contained eight classes, viz., agricultural land, forest, shrub land, grassland, built-up area, waterbody, snow/glaciers, and barren land, from which the agricultural data layers of the study districts were extracted for further analysis. The delineated masks were manually edited using on-screen visual interpretation methods simultaneously with Google Earth images to improve the overall demarcation of the agricultural land class. This editing

procedure was used because the LULC dataset was based on automated spectral image processing procedures at the national level, which, if left unedited, could have produced erroneous estimates at the district and village development committee (VDC) levels.

Mask delineation for each district began with the creation of a baseline reference dataset for 2010. We used this data as the starting point due to the availability of high-resolution 2010 images on Google Earth. The agriculture mask for 1990 was then edited retrospectively using the 2010 data as a template. The baseline 2010 agriculture mask, the 1990 Landsat imagery, and the 2010 Landsat imagery were displayed on the computer screen, allowing us to pan through the entire area covered by an agricultural mask of 1990, examining the 1990 and 2010 Landsat imagery and any relevant Google Earth imagery for valid changes between the two dates. Any misclassifications were manually digitized on-screen. This manual process eliminates errors that may arise between independently created LULC products for two dates and then differentiates them in a subsequent change analysis. We then divided the study area into 67, 50 and 90 grids of 5 × 5 km for Lamjung, Nuwakot and Chitwan respectively to conduct the accuracy assessment using Google Earth imagery.

Google Earth-based high-resolution satellite images are widely adopted for the verification of classified land cover products (Cohen et al., 2010; Gong et al., 2012; Lei et al., 2017; Olofsson et al., 2013).

Agricultural area changes and trends were observed at the district level. Successively, we delineated the agriculture mask for all the VDCs in each district. Following this, the changes and trends were observed at the VDC level.

3.4. Logistic regression and selection of variables

In the logistic regression model, 'contraction of agricultural land' is considered as a variable of agricultural land use change. The following equation (Eq. (1)) was used to analyse empirically the relationship of socioeconomic, climatic and physical factors with the dependent dichotomous variable of contraction of agricultural land.

$$Pi = E(Y = 1|Xi) = \frac{1}{1 + e^{-(\alpha + BiXi)}} \quad (1)$$

Where Pi represents the probability of contraction of agricultural land. For ease of exposition, this equation is written as

$$Pi = \frac{1}{1 + e^{-Zi}} = \frac{e^{Z}}{1 + e^{Z}} \quad (2)$$

Where

$$Zi = \alpha + BiXi$$

α is constant, Xi is the vector for independent variables and Bi is the vector for coefficients of independent variables.

If Pi, the probability of contraction of agricultural land, is given by Eq. (1), then $(1 - Pi)$ is the probability of no contraction in agricultural land

$$1 - Pi = \frac{1}{1 + e^{Zi}} \quad (3)$$

Therefore, we can write

$$\frac{Pi}{1 - Pi} = \frac{1 + e^{Zi}}{1 + e^{-Zi}} = e^{Zi} \quad (4)$$

Now $\frac{Pi}{1-Pi}$ is simply the odds ratio in favour of contraction of agricultural land – the ratio of the probability that agricultural land will contract to the probability that it will not contract. Based on the data on agricultural land use change between 1990 and 2010 in the basin, we categorized the VDCs as those with expansion of agricultural land and

Table 3
Description of variables and hypothesized signs.

Main dimension	Variable	[a]Type of variable	Description of variables	Hypothesized signs of variables in the regression model	Data source	Reference for *a priori* sign
Dependent variable						
Contraction of agricultural land (D_1)			If the proportion of agricultural land in total VDC land reduced in 2011 compared to 1991, D = 1; Otherwise 0		rds.icimod.org, Uddin et al., 2015	
Independent variables						
Socioeconomic	Education (X_1)	Control	Population with SLC[b] and above qualification (%)	+	CBS (2011)	Hussain et al., 2016; Pathak et al., 2017; Rasul et al., 2014
	Male internal migration (X_2)	Independent	Proportion of male domestic migrants in total male population (%)	+		Community consultation
	Male international migration (X_3)	Independent	Proportion of male international migrants in total male population (%)	+		Community consultation and several studies
	Female internal migration (X_4)	Independent	Proportion of female domestic migrants in total female population (%)	+		Community consultation
	Female international migration (X_5)	Independent	Proportion of female international migrants in total female population (%)	+		Community consultation
	Population density (X_6)	Control	Number of people in a square km	+		Josephson et al., 2014; Muyanga & Jayne, 2014
Physical	Slope (X_7)	Control	Mean slope (degree)	+	SRTM 90 m	Tiwari and Joshi (2012)
	Aspect (X_8)	Control	Horizontal orientation of ground surface (0°−360°)	+	SRTM 90 m	
	Ecological zone (D_2)	Control	If mountainous and hilly districts, D = 1; Otherwise = 0	+		ICIMOD (2008)
Climatic	Precipitation (X_9)	Control	Mean annual precipitation (mm)	−/+	Worldclim	Hussain et al. (2016)
	Temperature (X_{10})	Control	Mean temperature in the warmest months (°C)	−/+	Worldclim	Sivakumar & Stefanski, 2010

Note: Census 2011 define absentee or migrant members as the household members staying away from home for more than 6 months in a year, but still considered as member by the household.

[a] Independent variables refer to key factors, which are the main focus of this study. To capture the effect of other key factors, 'control variables' are taken into account.

[b] School Leaving Certificate.

those with contraction of agricultural land in 2010 as compared to the base year 1990.

Following the latest census of Nepal (2011), we define an absentee as the number of people who the household considered to be household members who are away from the household for more than 6 months in a year. When the destination of such absentee member is within the country, they are considered as internal migrant and when abroad international migrant. To identify the most appropriate independent variables related to migration, a consultation with local communities was organized to guide our categorization of migration into internal and international, and disaggregate this information by sex (of the migrant). Two out of the three selected districts (Nuwakot and Chitwan) are among the top ten source districts for female international labour migration (DoFE, 2016). During the consultation, locals explained that the role of women in agriculture has increased due to the outmigration of men. When men migrate, women undertake the overall responsibility of household farming activities/decisions. However, when women start to outmigrate too in significant numbers, it may negatively affect agricultural activities. Taking this into account, we hypothesized a positive sign of the influence of both male and female migration on agricultural land contraction.

To ensure the internal and external validity of estimates, other most relevant socioeconomic, climatic and biophysical factors (control variables), as well as their *a priori* sign of influence, were identified based on literature review and consultations with local communities. The identified variables together with their *a priori* sign are presented in Table 3. Local communities also highlighted 'agricultural productivity' as an important factor that influences decisions on agricultural land use. However, the study could not incorporate a productivity variable due to the non-availability of reliable data at the VDC level and this is an important limitation of the study.

Table 4
Summary of PRA methods and purpose.

Method	Purpose
Semi-structured interviews with villagers from selected VDCs in Chitwan, Nuwakot and Lamjung districsa	• Discuss about the trend of agricultural performance over the past 3 decades. • Collect perceptions on the major challenges to agrarian sector • Discuss about migration trends in the villages. • Gather information on the drivers behind the increase in agricultural land abandonment in Nuwakot and Lamjung; and on land conversion (forest to agriculture) in Chitwan. • Collect perceptions on the linkage between migration and agriculture land abandonment.
Field Observation	•Visiting selected plots in the village to verify the agricultural land classification as shown by geospatial analysis. •Observe the state of vegetation and conversion (if any) of the abandoned land.
Semi- and unstructured interviews with officials, NGOs, professionals	•Chief and Deputy-chief, Institute of Agriculture and Animal Sciences, Lamjung – Performance, challenges and potential of agriculture in mountain context; youth and the agriculture sector. •District Chamber of Commerce and Industries – major crops grown, traded in the district, challenges facing agriculture sector •NGO professionals: increasing migration, agriculture land abandonment, developmental dilemmas. •Local School Teachers: increasing migration, agriculture land abandonment. Impact on education. •Community leaders: increasing migration, agriculture land abandonment. Development and planning issues.
Focus Group Discussions 13 FGDs (8 mixed; 5 with women's groups. Participants ranging from 20 to 90 years)	• Verification of changes in agricultural land classification between 1990 and 2010 using A5 maps at ward level. • Perceived changes in agricultural land in the period 2010–2017. • Major perceived changes in agriculture over the last decade. • Challenges in agriculture over the last decade. • Discussion on migration trends in the village and overall impact of migration. • Discussion on the increase in agricultural land abandonment in Nuwakot and Lamjung/on land conversion in Chitwan. • Discuss about the linkage between migration and agriculture land abandonment

3.5. Participatory research

We triangulated the findings of agricultural land use change and regression analysis with stakeholders perceptions and field observations. The data were collected using a participatory rural appraisal approach comprising of semi-structured and unstructured interviews and focus group discussions (FDGs).

A summary of the methods is provided in Table 4. In total, we conducted 7 key informant interviews (KIIs), 16 individual interviews, and 13 FGDs (8 with mixed groups and 5 with women's groups). We ensured to cover all age groups and to have sufficient women's representation and young people (15–24 years old, as defined by the United Nations). We specifically targeted areas where women and the youth gather (e.g. markets, schools, homes and fields). The interview participants were aged between 20 and 90 years and from different castes and ethnicities. Before selecting the VDCs, a preliminary analysis showed that overall agricultural land in Chitwan district increased between 1990 and 2010. However, in the other two districts, agricultural land decreased during the same period (Fig. 3). So it was appropriate for us to select purposively only those VDCs that showed the highest change in agricultural land use (increase or decrease) to understand in-depth the factors behind these changes. We selected two VDCs from each district: two VDCs with maximum change and continuous decline in agricultural area were selected from Lamjung (Bahundanda and Chiti) and Nuwakot (Duipipal and Thansing) districts respectively. In Chitwan district we selected two VDCs (Jutpani and Shaktikhor) with continuous growth in agricultural land area.

During the FGDs and KIIs, participants were asked to share their perceptions about changes in agricultural land use in their respective VDCs (in the last decade 2010–2017), as observed in the geospatial analysis (for the period 1990–2010), using the ward level A5 sized google earth maps. They were asked to detail when and why these changes occurred, including the performance of agriculture sector (kinds of crops grown earlier, the growth/loss in productivity) in the last 3 decades (1990–2017). They were also asked to share their views on the determinants and future trends in land use. Similarly, perceptions of trends and issues around labour migration were discussed.

4. Results

4.1. Agricultural land use change from 1990 to 2010

The analysis of agricultural land use change showed a declining trend in agricultural area in Lamjung and Nuwakot districts, whereas it showed an increasing trend in Chitwan district (Fig. 3). During this period, the area under agriculture decreased by 2225 ha in Lamjung and 2251 ha in Nuwakot, respectively, while an increase of 2927 ha was observed in Chitwan. During community consultations in Chitwan,

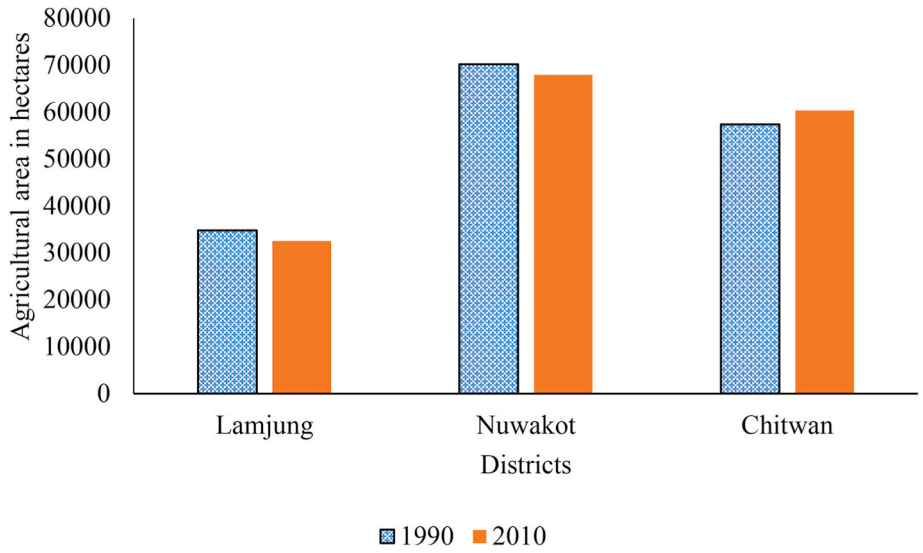

Fig. 3. Scale of agricultural land use change from 1990 to 2010 for Lamjung, Nuwakot and Chitwan (in hectares).

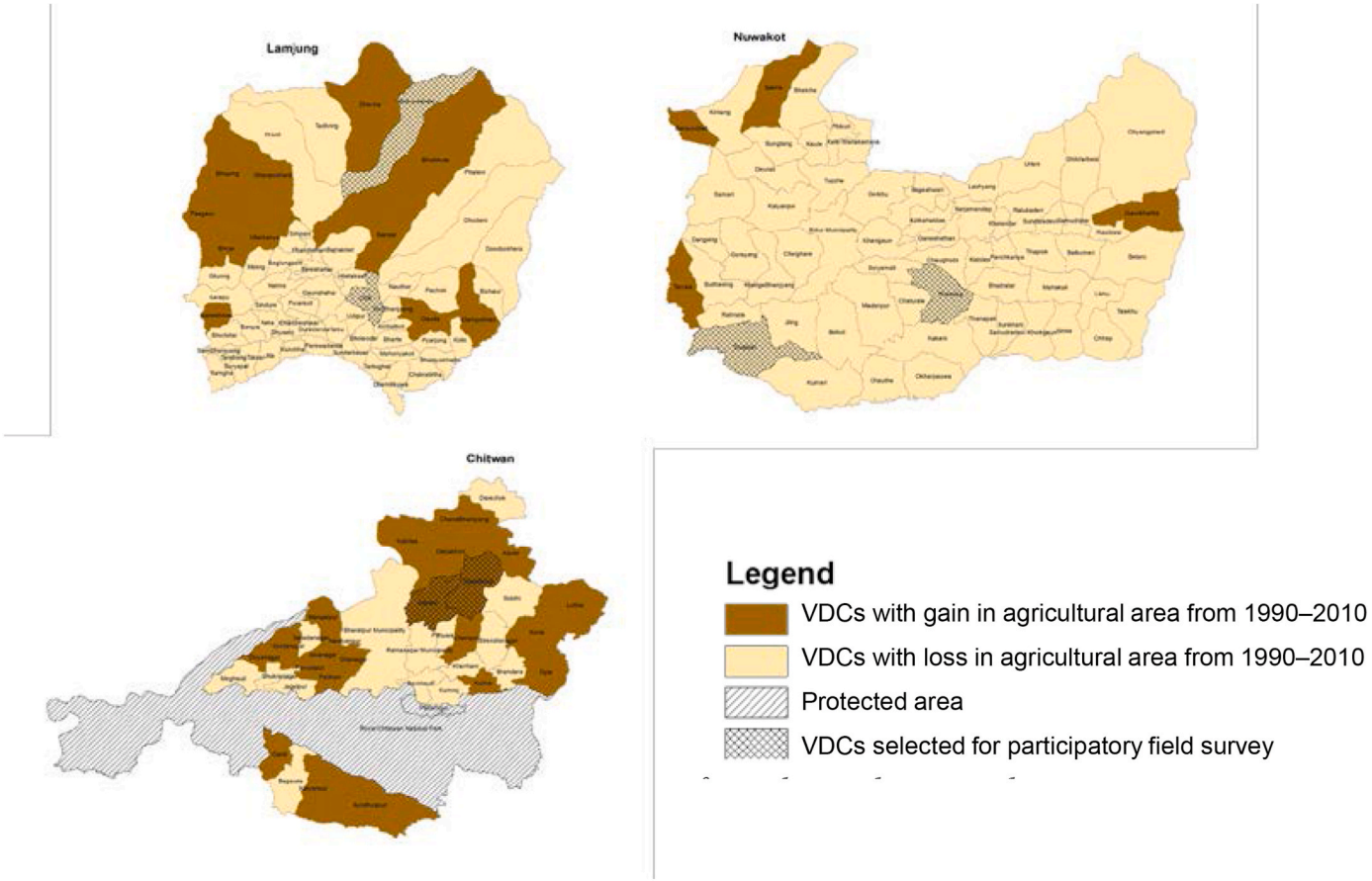

Fig. 4. VDCs from the study areas showing expansion or contraction in agricultural area.

reasons for the expansion of agricultural land (converted from forest land) were identified and further verified based on secondary information and literature. The two major reasons were the relocation of Padampur village from inside the Chitwan National Park (Protected Area) to Jutpani VDC during 1995–2004 (Dhakal et al., 2011); and the resettlement of flood-displaced people, particularly after the devastating Lothar and Rapti floods of 1993 (Singh, 2013). In both cases, forest land was cleared for the resettlement. The major reasons cited for agricultural land contraction in Nuwakot and Lamjung pointed at educated people giving up subsistence agriculture, and erratic precipitation hampering rainfed agriculture.

Our results confirm the overall trend of expansion of agricultural land in the Terai and contraction in the mountains, reported by previous studies for Lamjung (Paudel et al. 2012; KC & Race, 2019), Kavre (Schwilch et al., 2017; Thapa, 2001), and Kaski (Awasthi et al., 2002; Khanal, 2002; Khanal & Watanabe, 2006) districts.

Table 5
Descriptive statistics of variables. The results of the regression analysis showed the influence of some important factors on the contraction of agricultural land (Table 6).

Main dimension	Variable	Mean value	Standard deviation	Min	Max
Dependent variable					
Contraction of agricultural land (D_1)		0.79	0.41	0	1
Independent variables					
Socioeconomic	Education (X_1)	13.42	6.32	1.3	37.3
	Male internal migration (X_2)	19.49	12.10	0	57
	Male international migration (X_3)	18.08	10.59	1	45
	Female internal migration (X_4)	12.38	8.19	0	36
	Female international migration (X_5)	1.89	1.36	0	8
	Population density (X_6)	307.31	304.11	10	2122
Physical	Slope (X_7)	19.17	8.85	0.5	33.4
	Aspect (X_8)	184.2	32.85	93	258
	Ecological zone (D_2)	0.77	0.42	0	1
Climatic	Precipitation (X_9)	1930.32	582.39	407	2922
	Temperature (X_{10})	23.55	5.10	3.4	29

Table 6
Factors influencing agricultural land use change: Estimates of Logistic Regression.

Variable	Coefficients	Standard errors	z-values	Odds ratio
Education (X_1)	0.1627***	0.0624	2.61	1.176
Male internal migration (X_2)	−0.1595*	0.0947	−1.68	0.852
Male international migration (X_3)	−0.0512	0.0370	−1.38	0.950
Female internal migration (X_4)	0.30770**	0.1565	1.97	1.360
Female international migration (X_5)	0.1444	0.2624	0.55	1.155
Population density (X_6)	0.0011	0.0011	0.93	1.001
Slope (X_7)	−0.0072	0.0606	−0.12	0.993
Aspect (X_8)	0.0008	0.0094	0.08	1.001
Ecological zone (D_2)	2.5733**	1.2878	2.00	13.108
Precipitation (X_9)	0.0017**	0.0007	2.11	1.002
Temperature (X_{10})	−0.1315	0.1128	−1.17	0.877
Interaction term ($X_6 \times D_2$)	0.0042	0.0032	1.30	1.004
Constant	−2.2439	4.1095	−0.55	0.106
Log likelihood	−45.2028			
LR Chi^2	75.11			
Prob > Chi^2	0.0000			
Pseudo R^2	0.4538			
Number of observations	160			

Dependent variable: Contraction of agricultural land (dummy variable).
Significance levels: ***p < 0.01, **p < 0.05, *p < 0.10.

Table 7
Population density in the study districts.

Districts	Population density (persons per square kilometre)			Change in population density (%)		
	1991	2001	2011	1991–2001	2001–2011	1991–2011
Lamjung	91	105	99	15.4	−5.7	8.8
Nuwakot	219	257	248	17.4	−3.5	13.2
Chitwan	160	213	261	33.1	22.5	63.1

Source: CBS, 2011.

The contraction and expansion in agricultural land observed in the three districts is not consistent across the VDCs within these districts (Fig. 4). The results show high variation among the VDCs in Lamjung than in Nuwakot and Chitwan districts.

4.2. Factors influencing agricultural land use change

In this section, we present the results of the logistic regression analysis. We start by presenting a descriptive analysis of the study sites/VDCs. In the study areas, the proportion of agricultural land to the total area declined in 79% of the VDCs in 2010 compared to the base year 1990 (Table 3). Statistics show that around 14% of the population are educated up to the high school level (School Leaving Certificate in Nepal) and above. The average population density of the area is nearly 308 persons per square kilometre. Of the total male population, around one-fifth has migrated within the country (internal migration) and a similar proportion outside the country (international migration). Thus, overall, around 40% of the male population has outmigrated from the area (Table 3). On the other hand, only 14.3% of the female population has migrated, and mostly within Nepal (12.4%), reflecting barriers to the mobility of women. Among physical factors, the mean slope of the study area is 19.17°, and mean aspect is 184°. A dummy variable (ecological zone) was created to capture the agro-ecological differences between the mountainous districts of Nuwakot and Lamjung, and the Terai district of Chitwan. Statistics of the ecological variable show that 77% of VDCs in the study districts are mountainous (Table 5). The mean annual precipitation is around 1930 mm and the mean temperature in the warmest months is 23.55 °C, with significant variation across the VDCs.

Among the main independent variables on migration, internal migration of men and women showed a statistically significant relationship with agricultural land contraction. However, male internal migration showed the negative relationship, and internal female migration showed the positive relationship. Odds ratio reveal that there will be 15% less likelihood of land contraction if 1% rise in internal male migration is observed. On the other hand, there will be 1.36 times higher chances of land contraction if 1% rise in female internal migration is observed (Table 6). International migration in the case of both male and female did not show statistically significant relationship. However, influence of international migration cannot be ignored. Odds ratio showed that there will be 1.15 times higher chances of agricultural land contraction if 1% rise in female international migration is observed. However, the chances of agricultural land contraction will be 5% less if 1% increase in male international migration is observed (Table 6). These results validate the general hypothesis of this study that labour migration influences the agricultural land abandonment but the influence differs across gender and migration type.

Among other socioeconomic factors, education showed a statistically significant relationship with agricultural land contraction. Among biophysical factors, only the ecological zone has a statistically significant relationship with agricultural land contraction. Similarly, among the climate factors, precipitation also has a statistically significant relationship with agricultural land contraction.

5. Discussion

In this section, we discuss the integrated findings of the geospatial analysis, regression analysis and qualitative methods by dividing them in five thematic areas: type of migration, gender, education, population density and climatic factors.

5.1. International versus internal migration and ecological differences

We found different impacts of internal and international migration on agricultural land use change. Internal migration showed a statistically significant relationship with agricultural land contraction, which

was gender differentiated, as detailed in the next section. Conversely, international migration (of both men and women) did not have a statistically significant relationship with agricultural land contraction. Our finding contradicts the general narrative in Nepal that the loss of youth to international migration is a major for agricultural land abandonment (Adhikari & Hobley, 2011; Jaquet et al., 2015; Khanal, 2002; Paudel et al., 2014; Tamang et al., 2014).

This finding was discussed in-depth during our community consultations. During interviews in all six VDCs, the respondents reported high international migration of youth to diverse destinations, yet their perceptions of the relationship between migration and agriculture abandonment varied. In Chitwan, respondents were convinced that international migration is not a major driver for agricultural land abandonment. On the contrary, in Lamjung and Nuwakot, respondents reported that international migration of youth is the main reason for agricultural land abandonment. This is consistent with the generally held narrative in the country that tends to stigmatise international migrant workers and hold them responsible for negative transformations of the rural economy and livelihoods. Delving deeper into the divergent narratives from Chitwan and Nuwakot/Lamjung, during the FGD the participants in all three districts were asked to elaborate on these differences.

Agriculture is more competitive, mechanized and commercialized in Chitwan as compared to Nuwakot and Lamjung. The labour loss effect of outmigration is easily offset by new hiring of labour or use of machines in Chitwan (Bhandari and Ghimire, 2016), which is not an option in Nuwakot/Lamjung. In Chitwan, farming is profitable and an attractive venture for remittance investment. For example, it was reported that the wives of migrant men in Shaktikhor VDC invest remittances for renting in land to cultivate beans. Furthermore, attractive returns from agriculture and integration to markets have increased the land value in Chitwan. So even when migrant families are unable to cultivate their land, they can easily rent it out. Land rent ranges from USD 592 to 888 per hectare per annum in Jutpani and Shaktikhor VDCs.

The situation in Lamjung or Nuwakot, is very different, as people perceive the migration of youth as a driver for land abandonment. Beyond agro-ecological differences, there is the fact that subservient castes that used to work the land are now resorting to off farm employment, and issues around land-ownership may prevent further investments in agriculture (See Ojha et al., 2017 for Lamjung).

Clearly migration can fuel both processes 'deactivation' and 'repeasantization' in agriculture (Sunam & McCarthy, 2016). No direct/linear linkage between international migration and agricultural land abandonment can be assumed, as the impacts of migration can be offset by factors such as remittances, mechanization of agricultural operations and improved market access.

The difference in agricultural land use between the Terai and the mountains is further evidenced from the findings pertaining to the variable agro-ecological zone. Among the biophysical factors, the variable for ecological zone had a statistically significant positive relationship with agricultural land contraction, showing 13 times higher chances of agricultural land contraction in mountain areas than in the Terai. The mountain and Terai districts differ significantly in physical, socioeconomic and climatic aspects (see Section 2). In a globalized economy, mountain agriculture cannot compete with the agriculture of the plains, except for some niche crops such as coffee, cardamom, and traditional crops, i.e. barley, millets and native pulses. In mountain agriculture mechanization is extremely difficult given the terrain, and this makes farming a physically demanding job. And the overall productivity and profitability of farming is lower in mountains compared to plains. Similar findings have been reported by other studies in the mountains of Nepal (Blaikie et al., 2002; Jefferson, 2016; Pain et al., 2014; Paudel et al., 2014) and elsewhere (Baldock et al., 1996; Garcia-Ruiz & Lasanta-Martinez, 1990; Kamada & Nakagoshi, 1997; MacDonald et al., 2000; Romero-Calcerrada & Perry, 2004; Walther, 1986).

5.2. Gender, internal migration and agricultural land contraction

The logistic regression shows the gendered dimension of the impact of internal migration on agricultural land use change. It is interesting to note that with a 1% increase in internal outmigration of men, there are 15% fewer chances of agricultural land contraction. On the other hand, an increase of 1% in internal outmigration by women is likely to increase the chances of agricultural land contraction by 36%. This reveals that internal outmigration of women impacts agricultural land use change more compared to internal outmigration by men. This is an interesting finding that the community consultations helped understand more in detail. When men migrate the remaining family members, particularly women, continue to cultivate the land. However, when women migrate, often looking for better education and health facilities for their children, there is only older people left in the household, thus leading to abandonment of agricultural work. For instance, in wards 2 and 3 of Bahundanda VDC in Lamjung district, the development of hydropower plants has provided employment opportunities for men. While men work in the hydropower plants, their wives have migrated to urban areas (mostly Besisahar) with their children, abandoning agricultural land as they seek better educational opportunities for children. Nonetheless, the major role played by women in agriculture clearly emerged in the gender-differentiated views they held on the performance and future of agriculture. Men tended to be more dismissive and less interested in the future of agriculture. Women's answers were far more concrete and hopeful. While recognizing the challenges, women respondents were clear in identifying needs and required interventions, leaving more space for positive improvements in mountain agriculture.

5.3. Education, changing aspirations, and agricultural land contraction

Education increases the likelihood of agricultural land contraction. Results show that there are 18% higher chances of contraction of agricultural land if the percentage of the population with education up to the SLC (secondary) level and above increases by 1%. This finding confirms the general narrative that the aspirations of the youth, particularly of those who are educated, are shifting from agriculture-based to non-agriculture-based sectors. This was also expressed by the youth in the focus group discussions and in individual interviews during the field consultations. Also educated people have higher chances of entering the salaried job market and thus they abandon agriculture to work elsewhere (Gartaula et al., 2012; Hoermann et al., 2010; Sunam & McCarthy, 2016). Chitwan and Lamjung are ranked 6th and 22nd in terms of literacy status and Nuwakot ranked 54th out of the 75 districts of Nepal (CBS, 2014).

5.4. Population density and agricultural land contraction

An increase in population density is likely to increase the chances of agricultural land contraction (Table 5). However, the relationship between these two variables is statistically non-significant. To further investigate the differential effects of population density across ecological zones (mountains and plains), an interaction term of population density and ecological zone was incorporated in the model. The results show that an increase in population density in the mountains may result in higher chances of agricultural land contraction than in the plains. However, the relationship between interaction term and agricultural land contraction remained statistically non-significant.

The positive relationship of population density with agricultural land contraction is consistent with earlier studies (Josephson et al., 2014; Muyanga & Jayne, 2014). This relationship is plausible as an increase in population will require more land for housing, which may result in contraction of agricultural land, as reported elsewhere (Gautam et al., 2003).

Among the three study districts, Chitwan has had the highest population density as well as growth rate since 1990 (see Table 6).

Chitwan district has the largest urban area among the three selected districts. Although we observed an overall increase in agricultural area from 1990 to 2010, certain pockets showed a decrease in agricultural land coinciding with urban expansion. Urban areas such as Bharatpur and Ratnanagar municipalities and the surrounding areas in Chitwan district reported high population density and high agricultural land contraction. During field consultations in Jutpani and Shaktikhor VDCs of Chitwan, people reported high in-migration from the hill and mountain districts of the Gandaki River basin, particularly from Lamjung, Dhading, Gorkha and Baglung districts, leading to urban expansion.

5.5. Climatic factors and agricultural land use change

Precipitation is likely to increase the odds of agricultural land contraction. If annual precipitation in the study areas increases by 1 mm, it may increase the likelihood of agricultural land contraction by 0.2%. This finding is consistent with climate projections for mountain areas (IPCC, 2013, 2014). The HKH region is highly vulnerable to erratic weather conditions such as high-intensity rainfall leading to frequent floods (Ailikun, 2015; UCCRN, 2015). Daily precipitation exceeding 144 mm increases the risk of landslides on mountain slopes (Dahal & Hasegawa, 2008), negatively affecting arable land (Tiwari & Joshi, 2012). The frequency of such precipitation-induced hazards has increased in Nepal in the last 10 years (Hussain et al., 2016). However, changes in temperature did not show any significant effect on agricultural land use change.

Though climatic factors did not show a strong effect on agricultural land use change, during community consultations, a majority of respondents in the mountain districts reported that drying up of natural springs has made farming difficult, once again highlighting the importance of an interdisciplinary research approach. Springs are a major source of drinking and irrigation water in the mountains and their drying up is a serious concern for households. For example, 75 households (out of 85) of Belaspur village in Nuwakot district had to relocate because of springs drying up (Pokharel, 2017). This is the result of complex and multiple factors, climate being only one of them, and the problem needs to be investigated further, considering the importance of springs in the livelihoods of mountain people.

6. Conclusion and policy implications

Migration has both positive and negative impacts on agriculture in Nepal. Drawing on the case of three districts – Chitwan, Lamjung, and Nuwakot from the Gandaki River Basin, the study analysed the influence of labour migration on agricultural land abandonment. We found an increasing trend of agricultural land contraction in the mountain areas (about 2200 ha) and expansion in the Terai (about 2900 ha) from 1990 to 2010. Findings revealed the differential impacts of internal and international migration on agricultural land use change. Contrary to the general narrative, international migration did not have statistically significant effect on the contraction of agricultural land, while internal migration had a significant effect. Community consultations helped to validate this finding, which contradicts previous results from household surveys measuring self-reported reasons for agricultural land abandonment. The study finding highlights the role played by complex interactions of processes at various scales in agricultural land abandonment. Labour market dynamics, the ability to overcome loss of labour due to outmigration, and competitiveness of agriculture to attract investment are some of the most reported factors.

The differential trend of agricultural land use change in the mountain and Terai districts implies that increased commercialization of agriculture can reduce agriculture abandonment. This finding underscores the importance of increasing the competitiveness of the agriculture sector and investments in mountain agriculture. In order to increase the competitiveness of mountain agriculture, more investment and innovation is needed to overcome mountain-specific barriers (inaccessibility, fragility and small scale of production) and improve opportunities. Apart from cereals (rice, wheat, maize), mountain niche crops with a comparative advantage need to be identified and developed. Commercialization of agriculture can generate employment and economic opportunities, including for the educated youth. However, without mechanization to reduce drudgery and costs, it will be difficult to attract youth to the agriculture sector.

The study provides further evidence of the central role of women in farming, as shown by the significant impact on land contraction caused by women's internal migration. Our findings also show that when men migrate internally, it leads to agricultural intensification, whereas internal migration of women leads to agricultural land abandonment, confirming the crucial role of women in agriculture. Even today, agricultural extension services are predominantly provided by men and target men, while the majority of service receivers are women (Goodrich et al., 2017). Future agricultural development in Nepal should place women at the centre of agricultural planning and policy. Efforts are necessary to promote gender-friendly technologies in agriculture and build their overall capacities to increase the productivity of available agricultural land and restore abandoned land.

Finally, risks in the agriculture sector are further aggravated by changing climatic conditions, particularly erratic precipitation. Our findings show that increased precipitation leads to agricultural contraction. Finally, a key issue highlighted by the local community is the drying up of springs. This variable was not included in the regression analysis due to lack of data. However, there is clearly a need for further studies on this crucial aspect of mountain livelihoods.

For a land scarce country with increasing dependence on food imports to meet the food demand, ignoring agricultural land abandonment can result in increased vulnerability/instability of food security situation in case of disruption of global food supply. Nepal has recently undergone a political transition, with a new constitution and the introduction of a three-tier governance structure: federal, provincial, and local. All three tiers have the constitutional power to enact laws, prepare budgets and mobilize their own resources. The interdisciplinary methodology used in this study is simple enough for local and provincial stakeholders to use in land use planning.

CRediT authorship contribution statement

Amina Maharjan: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, Writing - review & editing. **Ishaan Kochhar:** Methodology, Investigation, Formal analysis, Writing - original draft. **Vishwas Sudhir Chitale:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing. **Abid Hussain:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Giovanna Gioli:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing.

Declaration of competing interest

None.

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Appendix A. Supplementary data

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