

# An explanation of labor migration and grain output growth:

## Findings of a case study in eastern Tibetan Plateau

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**Abstract:** Although there has been rapid rural-urban migration in rural China since the 1980s, the total grain production of China saw a continuous increase. As of today, the relationship between labor migration and grain output growth remains partial and contradictory. The main aim of this empirical study is to examine some specific measures adopted by peasants to deal with labor shortage and maintain grain output growth. Using tracking survey, participatory rural appraisal methods, and land plot investigation, we investigate 274 households and 1405 arable land plots in four villages in two stages in Jinchuan county, southwestern China. The results show that continuous emigration of labor from the four villages caused the abandonment of a small amount of land, decreased labor intensity, and reduced multiple cropping index, shifting from “corn-wheat” multiple cropping pattern to the “corn” cropping pattern, which means labor shortage in some households. At the same time, owing to surplus labor in the villages, the peasants utilize a series of means to offset the negative impacts of labor migration on grain output, such as cropland transfer, labor exchange in the busy seasons, and the substitution of capital and technology for labor. The econometric analysis also shows that labor migration boosts grain production. This study provides a reasonable explanation of grain output growth under rural-urban migration.

**Keywords:** labor migration; land use change; labor intensity; capital intensity; grain output

## 1 Introduction

Since the 1980s, China has been undergoing a process of rapid out migration of rural labor to urban areas. According to the *China Statistical Yearbook* (1982–2011), the country’s urbanization rate increased from 20.91% in 1982 to 51.27% in 2012, showing 1.01% annual growth. Meanwhile, the rural population has a negative growth rate of 1.5% from 2001 to

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2007. However, the total grain output has been constantly increasing since the 1980s.

An explanation of labor migration and grain output growth in China is critical to formulate appropriate policies that would maintain the increase of grain production capacity. For example, a question that needs to be addressed is, will the trend of grain output growth stop in the near future, or decades later? If the former is true, the government must actively enact policies that boost grain output accordingly. Moreover, these policies should be based on a comprehensive understanding of the measures adopted by the peasants to mitigate labor shortage and promote grain output.

Case studies from other countries show that depending on the presence of surplus labor and the extent of labor market perfection, the withdrawal of labor from agricultural to non-agricultural activities may or may not negatively affect agricultural output (Bardhan and Udry, 1999). These studies have shown three scenarios in the linkages between labor migration and agricultural output: (1) If there is sufficient surplus labor, remittances from family members working in cities allow rural residents to purchase high-quality seeds, fertilizers, pesticides, herbicides, and other new technology and infrastructure to boost crop yields (Stark and Bloom, 1985; Lucas, 1987; Rozelle *et al.*, 1999; Dustmann and Kirchkamp, 2001; Woodruff and Zenteno, 2001; Brière *et al.*, 2002; Black *et al.*, 2003; Taylor *et al.*, 2003; Taylor and López-Feldman, 2010). (2) In the case of a thin labor market and in the absence of surplus labor, labor withdrawal can reduce the on-farm labor as well as the agricultural output (Lipton, 1980; Clay *et al.*, 1998; Macdonald *et al.*, 2000; Mochebelele and Winter-Nelson, 2000; Holden *et al.*, 2004; Strijker, 2005; Tzanopoulos *et al.*, 2007; Yamada *et al.*, 2007; Beyene, 2008; Brosig *et al.*, 2009; Gray, 2009). (3) In the situation of a well-functioning labor market, hired labor can substitute for lost family labor with compromising output (Oseni and Winters, 2009).

While the relationship between labor migration and the continuous grain output growth in China seems to fit in the first scenario, we must note that the case studies on such a relationship remain partial and sometimes in contradictory. Several empirical analyses in China find that participation in labor migration fosters household ability to invest on the farm (Rozelle *et al.*, 1999; Taylor *et al.*, 1999, 2003; De Janvry *et al.*, 2005), and case studies on the plain provinces of China show continuous increase of grain output as well as rapid increase of labor productivity (Hao *et al.*, 2013). However, other case studies find that emigration of agricultural laborers has caused the marginalization of agricultural land, which has resulted in arable land abandonment and decrease in labor intensity, thus posing the additional challenge of ensuring food security (Liu and Li, 2006; Chen *et al.*, 2009a; Tian *et al.*, 2009; Xin and Li, 2009; Tian *et al.*, 2010). A few studies have reported measures adopted to deal with labor shortage, such as substituting capital and technology for labor (Zhang *et al.*, 2008; Chen *et al.*, 2009a; Hao *et al.*, 2013) and land transfer between households to mitigate land abandonment (Yao, 2000; Kung, 2002; Jin and Deininger, 2007). However, as of date, there remains a lack of comprehensive research which quantitatively examines the relationship between labor migration and grain output growth on household scale. The previous studies are not sufficient to explain the fact of labor migration and grain output growth in China, at either village scale or country scale. Furthermore, the existing studies on this issue focus mostly on plain areas, with little information about the mountainous regions, especially the Tibetan Plateau.

In this study, we aim to investigate some specific measures adopted by the peasants to deal with labor shortage and maintain grain output growth. We conduct rural household surveys to compare land transfers, labor exchange, changes in labor intensity, and the substitution of capital and technology for labor between 2005 and 2010 in four villages of Jinchuan county in the upper reaches of the Dadu River watershed in Sichuan province, southwestern China. An econometric analysis was also conducted to test how labor migration affects grain output growth.

2 Study area

The study chose Jinchuan county as the case area, where it is located at the upper Dadu River watershed at the eastern edge of the Tibetan Plateau (Figure 1, Zhang *et al.*, 2002). The county is at a typical eco-fragile region and lies in the transitional zone between the Sichuan Basin and the Tibetan Plateau (Yan *et al.*, 2005). Specifically, our field investigation and data collections cover four villages at the Sha'er Township in Jinchuan county. The main reason for choosing the upper Dadu River watershed as the study area is that we have conducted land use studies here for many years and on different scales, thus accumulating a wealth of data. At the regional scale, we have studied the area's land cover changes (Yan *et al.*, 2005a), the driving mechanisms and spatial simulation of land-use changes (Bai *et al.*, 2004; Bai *et al.*, 2005; Yan *et al.*, 2005b), and the farmer and nomad livelihood diversification scenarios (Yan *et al.*, 2010a). At the village scale, we have studied farmer livelihoods and the land use of two out of the four villages in 2005/2005: Keerma village (Zhang *et al.*, 2008) and Danzhamu village (Yan *et al.*, 2009). In the Danzhamu case, we investigated livelihood strategy and land use between the collective system and the household responsibility system, and found crop structure adjustment, decrease of labor input, increase of chemical fertilizer input since the 1980s. In the Keerma case, Zhang *et al.* (2008) reported that

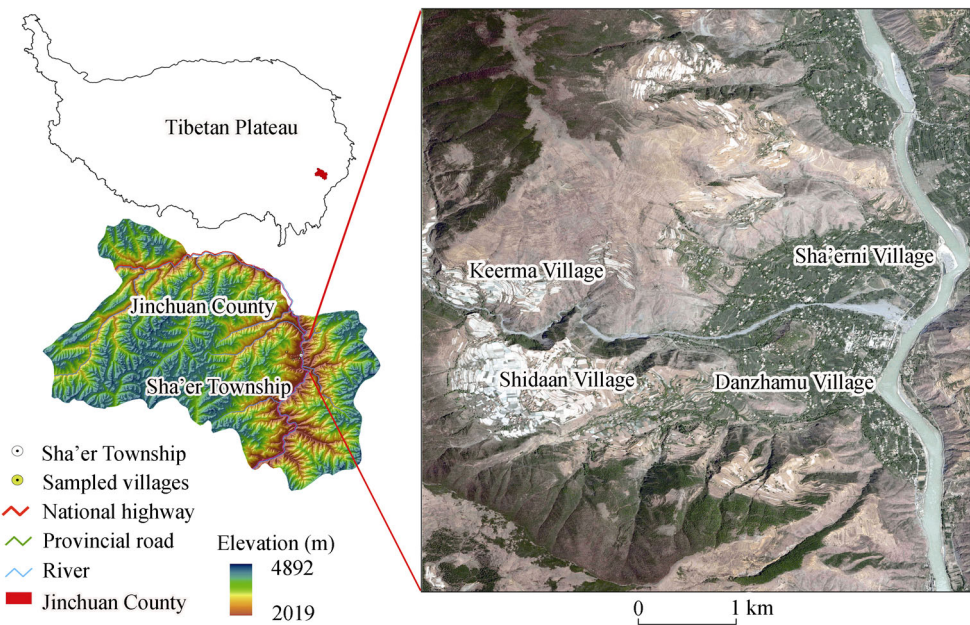


Figure 1 Location of the four villages at Sha'er Township, Jinchuan county

livelihood strategy affecting land use type and land use intensification level.

Jinchuan county is located in the eastern edge of the Tibetan Plateau between 31°04' to 31°58'N and 101°13' to 102°19'E, covering an area of 5524 km<sup>2</sup>. The landform in Jinchuan county tilts gradually from northwest to southeast with a few mountains of above 4000 m height. The Dadu River drains the area, forming a deep river valley with steep slope and dividing it into two types of morphologic regions – the southeast mountain canyon area and the northwest mountain plains. Due to the influence of latitude, altitude, surface variations, and the redistribution of water, heat and light, the climate there is complex and varies with long sunny days, temperature differences, clearly wet and dry seasons, and distinct vertical and seasonal differences (ECCJC, 2011). Sha'er township, located in the northeastern part of Jinchuan county, comprises valley and middle-mountain landform. The chosen Danzhamu and Sha'erni villages represent the agricultural area and Shidaan and Keerma villages represent agro-pastoral areas.

The Danzhamu and Sha'erni villages are located 4.0 km and 5.8 km away from the county town, respectively. The two villages have notable regional advantages because they are located in the flat areas of the river valley with low altitude and gentle terrain. They have complete irrigation canal systems for farmland and gardens, convenient transportation, and other necessary infrastructure. With increasing opportunities in the industry and service sectors, non-agricultural employment has gradually become the main income source in the villages. In 2010, there were 1835 residents occupying 438 households in Danzhamu village, and Sha'erni village had 1064 residents in 284 households.

The Shidaan and Keerma villages are located in the central and western parts of Sha'er township, 6 km and 10 km from the Jinchuan county town, respectively. They both have typical mountain canyon landform with large differences in elevation (2430 m to 4170 m), resulting in an agro-pastoral mode of land use with a farmland-based and imbalanced distribution of grassland resource. While Shidaan village has relatively few grassland resources, causing a large conflict between livestock feeding demand and pasture resource supply, Keerma village is located on the hillside with relatively abundant pasture resources. The two villages have the necessary infrastructure and adequate transportation systems. In 2010, there were 357 households and a population of 1490 in Shidaan village, and Keerma village had 110 households with 421 residents.

### 3 Methodology

#### 3.1 Tracking study and semi-structured interview

In order to understand the transitional track and explore the relationship between labor migration and grain output growth, we use the qualitative approaches which mainly contain a tracking survey and semi-structured interview, to gain an understanding of the changes of labor and production at first. This method, tracking study, is particularly suited for our study since we have mastered the knowledge based on the field surveys taken in 2005 and 2006 (Zhang *et al.*, 2008; Yan *et al.*, 2009). We conducted detailed sample surveys on the differences in rural household conditions in the four typical villages.

Our study adopted participatory rural appraisal (PRA) tools and the results presented in this paper are based on in-depth semi-structured interviews. The designed questions related

to family-member employment situation, changes in farmer livelihood strategies since the implementation of the land contract system, changes in land assets and land use (such as number and size of plots, nature of crops, fertilizers, and labor input) following land allotment to households, the number and type of livestock, livelihood assets such as shops and workshops, household income and expenditure, farmers' evaluation of living standards, awareness of livelihood vulnerability, and their future plans of livelihood. The first survey was conducted in two stages, the first in August 2005 and then from June to August 2006, and the second survey was also done in two stages, the first from May to August 2011 and then in September 2012. While the first survey involves livelihood and land use of 2005, the second survey covers that for 2010. The first survey received responses from 272 households, and the second one, from 274 households, with 216 households having been covered by both surveys.

We obtained the information on rural households-contracted cropland plots in the four villages through field survey. In our field survey, we selected sample plots, inspected plot archives, and numbered sample plots and recorded each sample's acreage, type of land use, situation of crop cultivation, and fertilizer input at the start of the land contract. Under the guidance of local peasants, we then conducted field surveys of individual plots and recorded their attributes. Information on households and plots are linked together later.

### 3.2 Econometric modeling

For better understanding of the driving forces of grain production, a conventional quantitative approach, multiple linear regression model, is utilized to address the factors affecting grain production by the peasants. The dependent variable is the change in grain production between 2005 and 2010 of a sample household (in kg). The multiple linear regression equation is as below:

$$y_i = x_0 + \sum \beta_i x_i + \varepsilon \quad (1)$$

where  $y_i$  is the dependent variable,  $x_0$  the constant term,  $x_i$  the explanatory variable,  $\beta_i$  the regression coefficient, and  $\varepsilon$  the random error term.

Following similar studies on factors affecting grain production (Qin *et al.*, 2011; Gu, 2013; Liu *et al.*, 2014), this paper includes explanatory variables on household characteristics, livelihood assets, input factors, and regional differences, as detailed below (Table 1).

(1) Household characteristics: The household head is the main decision maker on crop plantation of a household, and thus, the age and education level of the household head have an effect on grain production. In this paper, the age and education level of the household head in 2005 are chosen as explanatory variables.

(2) Change in livelihood assets: Income, cropland areas and labor arrangement are the three factors that were used in this study to represent livelihood assets of a household. Household income is composed of agricultural income, animal husbandry income, and off-farm income, as local people seek livelihood diversification. Change of income from animal husbandry between 2005 and 2010 is chosen as an explanatory variable. However, the change in off-farm income is not considered as an explanatory variable, as it is correlated with the change in total income (the correlation coefficient being 0.975) and the change in labor migration. Agricultural income is also not considered as an explanatory variable, as it

is correlated with grain production. The change in seeded area is chosen as an explanatory variable, as it reflects the changes in cropland area and cropping system. Labor arrangement between grain production and off-farm employment, e.g. the change in labor migration number between 2005 and 2010 is chosen as an explanatory variable.

(3) Change in production materials: Given the availability of data, the change in fertilizer inputs was selected as an explanatory variable to represent changes in agricultural capital investment. The number of plots (2005) to represent the degree of land fragmentation, as higher land fragmentation causes farmers to increase labor input but reduce the efficiency of grain production.

(4) Regional variables: There are large differences in the agricultural conditions between the valley and the middle-mountain areas, such as climate, soil, traffic conditions, and irrigation, and therefore, regional variables are introduced.

**Table 1** Variables and description of the econometric model

Variable	Description	Unit	Mean	Standard deviation
1. Household characteristics				
<i>Age of household head (2005)</i>	Age of household head in 2005	—	52.06	11.48
<i>Education level of household head (2005)</i>	Illiterate, elementary, middle, high school, college and above, assigned 1, 2, 3, 4 and 5, separately	—	2.23	0.79
2. Changes in livelihood assets				
<i>Change of labor migration</i>	Labor migration number of 2010–labor migration number of 2005	Individual	0.22	1.05
<i>Change of total income</i>	Total income of 2010–total income of 2005	10 thousand	2.16	2.79
<i>Change of income from animal husbandry</i>	Income from animal husbandry of 2010–income from animal husbandry of 2005	10 thousand	0.18	0.46
<i>Change of seeded area</i>	Seeded area of 2010–seeded area of 2005	1/15 ha	−0.14	3.27
3. Change in production materials				
<i>Change of fertilizer input</i>	Fertilizer input of 2010–fertilizer input of 2005	kg	223.88	220.5
<i>Number of plot in 2005</i>	Number of plots in 2005	—	3.50	1.88
4. Regional variables				
<i>Sha'erni</i>	Assigned 1, others 0	—	0.19	0.40
<i>Kerma</i>	Assigned 1, others 0	—	0.20	0.40
<i>Shidaan</i>	Assigned 1, others 0	—	0.27	0.44

## 4 Results

### 4.1 Characteristics of sample households

Although population size of the sample households remained constant in the study period, there is a slight reduction in the labor force (Table 2). Due to labor migration in this period, the households have a decrease of 0.4 units of agricultural labor force on average. As an in-

creasing number of people received education, the education level of the sample households had a slight increase and the illiteracy rate had a slight decrease. Simultaneously, there is an obvious trend of population aging. Compared to 2005, the proportion of people aged over 60 years increased by 4.52% in 2010, while the proportion of people aged less than 20 years had a 5.82% decrease.

From 2005 to 2010, the incomes of the sample households increased quickly and the income structure changed substantially. In 2005, income from non-agricultural employment, animal husbandry, and agriculture account for 74.88%, 14.86%, and 9.08% of total income, respectively. In 2010, the proportion changed to 81.41%, 10.50%, and 5.93%, respectively, showing a livelihood strategy relying more on non-agricultural employment.

**Table 2** Family characteristics of the sample households of the four villages in 2005 and 2010

		2010	2005
Average population per household		4.40	4.43
Average labor per household		2.84	3.04
Average non-agricultural labor per household		1.39	1.18
Average agricultural labor per household		1.45	1.86
Education level (%)	Preschool	5.16	5.12
	Illiteracy	14.10	14.64
	Primary school	35.79	39.85
	Junior high school	28.84	27.93
	High school	9.58	9.52
	College	6.53	2.93
Income (CNY)	Total income	33338.43	11751.55
	Non-agricultural income	27140.09	8800.05
	Animal husbandry income	3500.93	1746.48
	Farming income	1976.2	1067.16
	Other income	721.21	137.86
	Per capita income	7487.42	2791.45

4.2 Labor migration and labor exchange

The surveys of 2005/2006 have shown labor migration in Keerma and Danzamu villages during 1982–2006 (Zhang *et al.*, 2008; Yan *et al.*, 2009). There was notable labor migration between 2005 and 2010, and agricultural laborers have reduced by 22%. In 2005, there were 656 laborers in the four sample villages, with 255 non-agricultural laborers and 401 agricultural laborers, accounting for 26.67% and 41.95% of the total population, respectively. Of the 351 male laborers, 193 were non-agricultural, whereas of the 305 female laborers, only 62 were non-agricultural. In 2010, there were 613 laborers, with 300 in the non-agricultural and 313 in the agricultural sector. Of the 333 male laborers, 223 worked in non-agricultural sectors. Of the 280 female laborers, 77 worked were non-agricultural.

Not only the reduction but also the aging of the agricultural labor forces has affected labor force input in grain production. Figure 2 shows the age structures of the laborers in the study period. In 2005, 63 male agricultural laborers were less than 50 years old, while the number was reduced to 21 in 2010. The number of female agricultural laborers aged less than 50

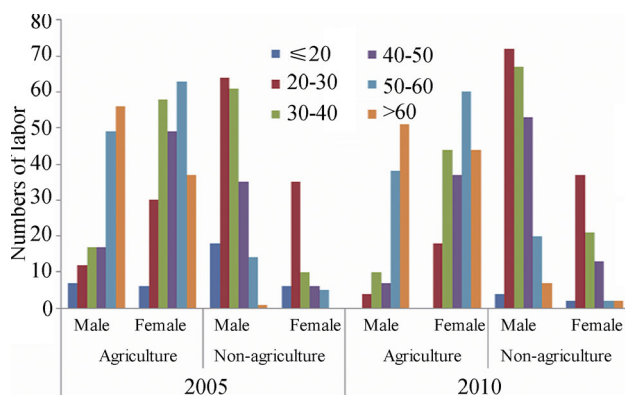
years also decreased from 143 in 2005 to 99 in 2010.

With the trend of labor migration, labor exchange has become a common phenomenon in grain production to respond to labor shortage in busy seasons, as agricultural labor hiring seldom occurs in the study area. Labor exchange refers to farmers casually seeking help from their relatives and neighbors for the agricultural production activities; while there is no monetary payment

involved, the hosts usually treat them with dishes. As there is a significant difference in households' land area between the valley area and the middle-mountain area, the average labor exchange days between the two areas differ greatly. The average labor exchange days in Keerma and Shidaan were 36.89 annually, four times as much as that in Sha'erni and Danzhamu (where the average is 9.00). The correlative analysis of the 216 sample households shows that the correlation coefficient between the number of agricultural laborers in a household and the number of labor exchange days in 2010 is 0.282 and is significant. A reasonable explanation is that more agricultural laborers in a household may imply more cropland area and sharp labor shortage in busy seasons, as mainly women and aged laborers stay at home during such seasons.

### 4.3 Land transfer

Table 3 shows land transfer, land abandonment, and land reclamation of the sample households. Among the 216 sample households, 212 households cultivated cropland in 2005 and 201 households cultivated cropland in 2010. The number of households who never cultivated croplands increased slightly in the five years, as laborers in those households are mostly indulged in off-farm employments. Compared with 2005, the area of cropland transferring increased in 2010. Of the total arable land, in 2005, 1.712 ha were rented out, while 2.558 ha rented in, and in 2010, 4.055 ha were rented out, while 7.725 ha rented in. Thus, the size of the rent-in land is more than that of the rent-out land. This is mainly because of emigration of a few households to the countryside, and thus, while we were unable to investigate the situation of land rent-out of those households, land rent-in data was available as their lands were rent in by some sample households. Because of labor emigration and the presence of greater rent-in land than rent-out land, land transfers could avoid the marginalization of arable land and land abandonment, and sown areas may therefore not be reduced. Cropland is mainly rented out by the households with labor migration because of the lack of an adequate agricultural labor force and poor benefits from farming. However, those households without labor migration have to rely on farming and want to expand the farming area. This is in line with the empirical studies conducted in Zhejiang, Hubei, Jiangsu, Shandong, Tianjin, and Guangxi provincial units in China (Zhong and Wang, 2003; Du and Huang, 2005; Chen *et al.*, 2008; Chen *et al.*, 2009b; Zou, 2008). However, according to a study on



**Figure 2** Age structure of labors of the sample households of the four villages in 2005 and 2010



Taipusi county on the ecotone of northern China, migrant workers are more willing to expand the scale of farming because of the easy substitution of capital and technology for labor force (Hao *et al.*, 2010). The difference lies in the average cropland area per household. In the study area of Taipusi county in Hao *et al.* (2010), the average cropland area per household ranges from 1.85 to 2.26 ha, implying the potential for small-scale farming. For example, if a farmer can rent-in 2 ha of cropland, he/she may have about 4 ha of cropland and the possible net profit from farming may reach 40,000 CNY annually, more than the current average of off-farm income. Therefore, the farmers are more willing to expand the scale of farming. However, in the Dadu River watershed, average cropland area per household ranges from 0.03 to 1.13 ha, without any potential to expand to a small-scale farm.

**Table 3** Land transfer and land abandonment of the sample households of the four villages in 2005 and 2010

	2005				2010			
	Households	Percentage (%)	Area (ha)	Area per household (ha)	Households	Percentage (%)	Area (ha)	Area per household (ha)
Farming	212	98.15	58.65	0.28	201	93.06	63.02	0.31
Rent out	16	7.41	1.71	0.11	41	18.98	4.06	0.10
Rent in	18	8.33	2.56	0.14	53	24.54	7.73	0.15
Abandonment	11	5.09	0.60	0.05	31	14.35	2.36	0.08
Reclamation	7	3.24	0.88	0.13	15	6.94	2.68	0.18

Land reclamation also existed in 2005 and 2010, mainly in Keerma and Shidaan. In 2005, there were seven households undertaking land reclamation, a total of about 0.88 ha. In 2010, there were 15 households that reclaimed 1.80ha land. The reasons of land reclamation are linked with the specific livelihood strategy of some households. Although all households sought off-farm income, some households with barriers to do so had to resort to land reclamation and land use intensification. Also, those households also raised more animals, as land reclamation may provide more corn for feed.

#### 4.4 Crop arrangements

Farmers' crop arrangements reflect changes in the crop type and labor intensity of land use (Yan *et al.*, 2010b). On the basis of discussions with farmers about assessing their labor-intensive level of crops, the crop arrangements are classified into three labor-intensive forms: zero-intensive (abandoned farmland), extensive(single crop), and intensive(double crop).

From 2005 to 2010, extensive land use increased dramatically, which is manifested by the shift from "corn-wheat" double cropping mode to single cropping mode, mainly corn (Table 4). This phenomenon is widespread in southern China, and is especially noticeable in the rice belt where "double cropping of rice has changed to single cropping of rice" (Xin and Li, 2009). In 2005, the proportions of extensive and intensive land uses in the sample plots are 64.53% and 35.46%, respectively. Due to the low level of productivity and technology, crop arrangements often focused on labor-intensive cropping patterns to meet domestic consumption. In 2010, the proportions of extensive and intensive land uses in the sample plots are 81.35% and 15.04%, respectively. The acreages of intensive use land have decreased 11.17 ha, that is, a proportion of 20.42%, and those of the extensive-use land and zero-intensive

land have risen 17.82% and 2.60%, respectively.

**Table 4** Land-use intensity of the sample plots of the four villages in 2005 and 2010 (ha, %)

Intensity of land use	Crop arrangement	2005		2010	
		Area	Percentage	Area	Percentage
Zero intensity	Land abandonment	0.6	1.01	2.36	3.61
	Corn	29.49	49.78	36.8	56.29
	Potato	0.38	0.64	0.75	1.15
	wheat	0.45	0.76	0.01	0.02
	Beans	0.35	0.59	1.86	2.85
	Pepper	0.19	0.32	0.59	0.90
Extensive use	Fruit tree	0.78	1.32	1.59	2.43
	Grass	0.27	0.46	0.30	0.46
	Corn intercrop potato	1.92	3.24	7.22	11.04
	Corn intercrop potato and beans	0.49	0.83	0.90	1.38
	Corn intercrop beans	2.55	4.30	1.53	2.34
	Potato intercrop beans	0.19	0.32	0.71	1.09
	Others	0.57	0.96	0.92	1.41
	Vegetable (two harvests a year)	0.58	0.98	0.37	0.57
	Corn + wheat + potato (beans)	0.18	0.30	0.46	0.70
	Corn + wheat	20.25	34.18	9.00	13.77
In total		59.24	100	65.37	100

#### 4.5 Considerable increase in capital intensity

Agricultural capital inputs comprise of inputs for increasing production and saving labor (Chen *et al.*, 2009b). Seeds, fertilizers, pesticides, and plastic films are major production-increasing investments, of which the first two are generally essential. Agricultural machinery and herbicides are major labor-saving inputs.

From the 1980s to the 2010s, capital intensity of the study area has significantly increased, which is consistent with the situation of the whole country. At the start of the land contracted in the 1980s, farmers had few choices in their selection of fine seeds. They reserved wheat seeds in advance, and purchased the *Jindan No. 4* corn seed because of its good quality and high yield. Currently, the farmers have more choices in selecting fine corn weeds, including varieties such as *Zhenghong No.2*, *Zhenghong 311*, *Adan No. 9*, *Yuhong No. 22*, *Chendan No. 9*, and *Chuandan No. 15*.

According to the 2005/2006 land plot survey, generally used fertilizers were poudrette, manure, plant ash and urea. Some farmers mainly used farmyard manure and a small amount of urea. In 2010, different types of fertilizers are used, for example, farmyard manures including poudrette, manure and plant ash, and chemical fertilizers including not only urea but also phosphate, ammonium bicarbonate, and compound fertilizer. The input of urea is also higher than that in the past. Compared to 2005, there are more fertilizer inputs and manure inputs in 2010, shifting from 631.02 kg/ha of fertilizer in 2005 to 1436.82 kg/ha in 2010, that is, nearly 1.7 times. The correlation coefficient between fertilizer input and agricultural

labor input is 0.292 and significant, which implies that when a household inputs more agricultural laborers, they are sure to input more fertilizers. However, the correlation coefficient between fertilizer input and non-agricultural labor input is not significant.

Labor-saving input increased significantly since the beginning of the land contract in the 1980s. In 1982, farmers in this area used few herbicides or other labor-saving pharmaceutical products and mechanical products. Nowadays, the farmers generally adopt herbicides or other labor-saving pharmaceutical products. Apart from dzos, farmers also use mini-tillers, tractors, and threshers. The proportion of input of farm cattle, mini-tillers, tractors, and threshers is 63.43%, 16.20%, 8.33%, and 31.48%, respectively. As the price of mini-tiller is expensive, 91.43% of sample households always rent a mini-tiller during busy seasons at the rate of 900–1500 CNY/ha. Herbicides are commonly used by all farmers to save weeding time. In 2010, nearly 66% of sample household use herbicides.

#### 4.6 Econometric analysis results

Total grain production of the 216 sample households is 514,383 kg in 2010, which is 32,165 kg more than that of 2005. Table 6 shows the regression results that help determine the causes for the continuous grain output growth despite the impact of agricultural labor migration. An analysis of the factors considered in this study, based on the regression results, is presented below (Table 5):

**Table 5** Estimated results of influencing factors on grain production of the sample households of the four villages

Variable	B	Standard errors	t	Sig.
1. Household characteristics				
<i>Age of household head (2005)</i>	-8.021	5.209	-1.540	0.125
<i>Education level of household head (2005)</i>	177.571**	78.646	2.258	0.025
2. Changes in livelihood assets				
<i>Change of labor migration</i>	101.559*	55.502	1.830	0.069
<i>Change of income</i>	-7.981	20.930	-0.381	0.703
<i>Change of income from animal husbandry</i>	242.039**	125.014	1.936	0.054
<i>Change of seeded area</i>	324.905***	18.837	17.248	0.000
3. Change in production materials				
<i>Change of fertilizer input</i>	1.110***	0.329	3.376	0.001
<i>Number of plot in 2005</i>	-69.936**	35.091	-1.993	0.048
4. Regional variables				
<i>Sha'erni</i>	97.211	156.235	0.622	0.535
<i>Kerma</i>	118.992	177.006	0.672	0.502
<i>Shidaan</i>	706.751***	172.829	4.089	0.000
Intercept	-68.296	403.663	-0.169	0.866
R <sup>2</sup>	0.877			
Adjust R <sup>2</sup>	0.769			

Note: \*\*\*, \*\* and \* represent significant level at 1%, 5% and 10%, respectively.

*Education level of household head (2005)*. The education level of the household head has

a positive effect on grain production and the estimated coefficient is statistically significant. A household head with a higher educational qualification may be more capable of processing information and applying it, and more inclined to use the mini-tiller, fertilizers, improved varieties, and herbicides to improve grain production.

*Change of labor migration.* The change of labor migration has a positive effect on grain production and the estimated coefficient is statistically significant. Although labor migration results in labor shortage, income from labor migration is transferred to other inputs for grain production. The substitution of capital for labor plays a great role and results in the increase of grain production.

*Change of income from animal husbandry.* The change in income from animal husbandry has a positive effect on grain production and the estimated coefficient is statistically significant. In the study area, agriculture and livestock husbandry are closely linked, by which agricultural products are used as feed for livestock, and the manure from livestock are used in the fields. In 2010, an average of 84.5% corn, 8.49% meat, and 35.6% tomato are used as feed. At the same time, the manure input was very high, averaging 10 748.98 kg/ha. Therefore, more livestock implies a greater need of feed from agriculture.

*Change of fertilizer input.* The change in fertilizer input has a positive effect on grain production and the estimated coefficient is statistically significant. Our explanation is that income from labor migration is used to buy fertilizer and other input factors which benefit grain production.

*Change of seeded area.* The change in seeded area has a significant positive effect on grain production and the estimated coefficient is statistically significant. Of the 216 sample households, 75 increased their seeded area, while 103 households reduced it, and the rest households maintained it. The main reason for seeded area change lies in the change of cropping system, primarily from “corn-wheat” to “corn”. Simultaneously, the introduction of improved variety induces a substantial increase of yield. For example, the yield of corn increases from 6790 kg/ha in 2005 to 7500 ka/ha in 2010, which can offset the slight reduction of seeded area.

*Number of plots in 2005.* The number of plots in 2005 has a negative effect on grain production and the estimated coefficient is statistically significant, which means that land fragmentation improves the traveling time between the plots, which reduce the efficiency of grain production.

*Regional variables.* Compared with the other three villages, Shidaan is located at higher elevation and the peasants raised more livestock, and therefore, more feeding is needed and the peasants have to cultivate more cropland to improve grain production.

## 5 Discussion

The nexus of labor migration and agricultural output growth of China are complex, while the case studies on such a relationship remains partial and sometimes in contradictory. On one hand, this study is consistent with previous case studies that peasants substitute capital and technology for labor (Taylor *et al.*, 1999; Zhang *et al.*, 2008; Chen *et al.*, 2009a; Hao *et al.*, 2013; Li *et al.*, 2013). Apart from the substituting of capital and technology for labor, we find more measures adopted by the peasants to offset labor shortage, including labor ex-

change in busy seasons, flexible crop arrangement and land transfer between households. On the other hand, this study confirms that labor migration results in arable land abandonment and decrease in labor intensity (Liu and Li, 2006; Chen *et al.*, 2009a; Tian *et al.*, 2009; Xin and Li, 2009; Tian *et al.*, 2010). As both phenomena appears in this case, an reasonable explanation is that labor shortage in some households and surplus labors in the villages coexist.

In this case, if we count cropland area per labor, there is still surplus labor in the four villages. By Huang's view (2014), one agricultural labor can manage 15 mu (1 ha=15 mu) of cropland. However, in this case, the number is only 2.23 mu in 2005 and 3.12 mu in 2010, as one household has only 4.71 mu on an average. If one laborer wants to perform its full cultivating capacity of managing 1 ha of croplands, he/she must rent-in croplands of more than two households, implying that nearly 2/3 of the households must migrate into cities or towns. However, until 2010, only 53 households rented in 7.725 ha of cropland. The strong man-land relationship in the mountainous region restricts the agricultural laborers from expanding the cropland area, and they have to resort to animal husbandry and other vocations. High levels of hidden unemployment in agriculture are frequently found. However, some aspects of the study area, such as abandonment of a small amount of land, labor aging, decreased labor intensity, and reduced multiple cropping index, imply that the labor migration results in labor shortage of some households. Owing to the surplus labors in the villages, labor exchange in busy seasons and cropland transfer between households can effectively offset labor shortage of these households.

Nowadays, there are heated discussions on whether China has passed the Lewis turning point and entered a new era of labor shortage from a period of unlimited labor supply. John *et al.* (2011) reported a puzzle of migrant labor shortage and rural labor surplus in China. On one hand, there are reports of migrant labor scarcity and rising migrant wages; on the other hand, estimates suggest that a considerable pool of relatively unskilled labor is still available in the rural sector. They conclude that for institutional reasons both phenomena are likely to coexist at present and for some time in the future. However, Zhang *et al.* (2011) holds that the acceleration of real wages even in slack seasons indicates that the era of surplus labor is over.

In the near future, the trend of labor shortage will get severe. During 2005–2014, the wages in manufacturing and service industries in the urban areas have rapidly increased, which have attracted the women and less-educated men who have been engaged in agriculture earlier to seek off-farm employment. Moreover, while migrating to the urban areas, the whole household typically prefers to move at once (Anwaer *et al.*, 2013). In the four villages, 15 out of 216 sample households are fully indulged in off-farm employment during 2005 and 2010. While this trend may accelerate in the future, the real number of household migration is hard to forecast. In addition, the elderly people currently managing the croplands may be too old to work in the next 10 years (Fan, 2003, 2004). If there is no surplus labor in the villages and the substitution of capital and technology for labor may not work in the near future, grain production is sure to decrease. Therefore, follow-up studies are needed to explore the capacity of labor-substitution measures and investigate the possible the turning point of surplus labor.

Previous studies have shown three scenarios in the linkages between labor migration and agricultural output in the world. As labor migration brings in labor shortage, this case does

not correspond to the first scenario of the relationship between labor migration and agricultural output. It does not correspond to the second scenario either, as there is continuous grain production increase. Finally, it does not fit in the third scenario too, as there is no labor market. As labor shortage in some households and surplus labors in the villages coexist, this case shows another scenario of labor migration and grain output growth. To understand the nexus of labor migration and grain output of China, future case studies should focus on the significant flexibility of rural households in responding to demographic change and the important ways in which these household strategies mediate population-environment relationships.

## 6 Conclusions

Although there has been rapid rural-urban migration in rural China since the 1980s, the total grain production of China saw a continuous increase. As of today, the relationship between labor migration and grain production growth remains partial and contradictory. This study considers four villages in the eastern Tibetan Plateau to investigate the measures adopted by the local peasants to respond to labor shortage and boost grain production. The preliminary conclusions come to the following:

(1) This study provides a reasonable explanation of grain output growth under rural-urban migration in China. The continuous emigration of labor in the four villages has resulted in the abandonment of a small amount of land, decreased labor intensity, and reduced multiple cropping index. This may mean that labor migration has brought in labor shortage in some households. However, as all households have relatively small cropland areas, the elderly and female, being largely home bound, can almost handle the farming work. At the same time, owing to surplus labors in the villages, the peasants utilize a series of means to offset the negative impacts of labor migration, including flexible crop arrangement, cropland transfer between households, labor exchange in busy season, and the substitution of capital and technology for labor.

(2) The econometric analysis confirmed that labor migration could boost grain production. Furthermore, the variables *Education level of household head (2005)*, *Change of income from animal husbandry*, *Change of fertilizer input* and *Change of seeded area* have positive effects on grain production and the estimated coefficients are statistically significant, while the variable *Number of plots in 2005* has a negative effect and the estimated coefficient is statistically significant.

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