Environment, Development and Sustainability
https://doi.org/10.1007/s10668-021-01539-1

Challenging slopes: ethnic minority livelihoods, state visions, and land-use land cover change in Vietnam's northern mountainous borderlands

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Received: 1 May 2020 / Accepted: 22 May 2021

Abstract

Sloping farmlands dominate much of Vietnam's northern borderlands with China. Here, ethnic minority farmers have relied on their traditional ecological knowledge for centuries to fashion sustainable semi-subsistence livelihoods as best they can. With a rapidly increasing agrarian transition, these farmers must now juggle the agro-ecological limits of their farmlands with new state agricultural policies, growing market integration, and increasing extreme weather events. Despite about 60 percent of Vietnam's landmass comprising slopes greater than 15°, there is sparse information regarding how best to support sustainable livelihood approaches in such regions. Yet, an understanding of current crop choices, agricultural limits, and farmer decision-making processes in such locales is vital for relevant, slope-related policy suggestions to be formulated. In this paper, we take a mixed methods approach, combining land-use and land cover (LULC) change mapping with qualitative interviews and observations, to investigate the interactions among sloping lands, LULC change, and local livelihoods in a remote, mountainous commune in northern Vietnam's borderlands. We analyze LULC maps for Bản Phố commune, Lào Cai province, which contains 13 ethnic minority Hmong villages and has a fairly typical upland topography with three-quarters of the land sloped over 15°. Focusing on three main findings from our LULC analysis we then determine the drivers and livelihood consequences of an increase of 'shrubs' on sloped land, specific pockets of conversion to 'bare soils', and an increase in particular urban areas. We find that state afforestation policies, lowland demand for 'authentic upland alcohols', and officials keen to raise the status of a nearby town, all factor into the challenges and opportunities farmers now face.

Keywords Livelihoods · Land-use land cover change · Sloping lands · Ethnic minorities · Hmong · Vietnam

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Published online: 08 June 2021

1 Introduction

In 2010, Vietnam initiated an ambitious New Rural Development Program (*Nông Thôn Mới*), with the explicit intent of modernizing farming and strengthening rural market integration. This has included a number of priorities that district and provincial state officials are strongly encouraged to adopt. These range from developing or upgrading socio-economic infrastructure such as roads, schools, health clinics, and administration offices, promoting the commoditization of agriculture including 'more appropriate' agricultural production methods such as the use of hybrid seeds, to improving rural enterprises and encouraging better trade links, among other goals (*Thủ tướng Chính phủ* 2010). This is one of numerous policies and programs that the Vietnamese state has introduced over the past twenty years to encourage rural 'development'. More specifically, the state has strongly encouraged a modernist development approach for the Vietnam northern uplands as a way to 'improve' and 'modernize' the livelihoods of the more than eleven million ethnic minorities who reside there in rural households (Jamieson et al., 1998; Turner et al., 2015). In these uplands, such policies have resulted in land and resource enclosures, legitimatized capitalist expansion, and sped up the cultural integration of ethnic minority communities into national ideals of 'modernization' and 'development' (Forsyth & Michaud, 2011). Such state endorsed-development projects are driving rapid upland livelihood changes, while at the same time these communities are experiencing and having to adapt to increasing extreme weather events (Delisle & Turner, 2016; Nguyen & Hens, 2019; Rousseau et al., 2019; Turner et al., 2015).

A large proportion of these upland ethnic minority households are undertaking farming on sloping lands. Indeed, it has been calculated that 60 percent of the country as a whole (20 million hectares), has slopes greater than 15° (Leisz et al. 2005). Within such a context, the contemporary strategies ethnic minority farmers pursue to maintain livelihoods are under-researched, leaving policy makers with sparse information regarding how best to support sustainable livelihood approaches on sloping lands. A small number of studies of land use and land-cover (LULC) change have been conducted in the central highlands, northern midlands, and northern uplands (e.g. Castella et al. 2005; Clement et al. 2009; Sikor, 2001). Yet, there is scant information on LULC in the high northern Vietnam borderlands (to our knowledge only Jardin et al., 2013; Trinsci et al., 2014; Turner & Pham, 2015). A smaller subset of studies again, have focused more precisely on the impacts of steep slopes on upland livelihoods in Vietnam. For example, Castella et al. (2006), working in northwest Vietnam illustrated the fragile nature of the environment in sloping uplands including declining soil fertility, as farmers increasingly moved to new varieties of maize and more market-orientated production. Also working in the northwestern uplands, Folving and Christensen (2007) explored the impacts of the introduction of agroforestry programs for sloping lands in local communities, noting the importance of locally adapted development strategies as certain farmers were willing to adopt the new programs and others remained more reluctant. Vu et al. (2013) also working in the northwest uplands, studied land use transitions over 40 years and found that slope was one of the biophysical features of the land, alongside elevation and soil type, impacting land use change decisions of ethnic minority farmers. Yet, while recognizing that slope is a critical factor in relation to upland ethnic minority livelihoods, none of these studies are located in Vietnam's high northern borderlands. Therefore, we wish to expand this literature while working to better understand the current crop choices, agricultural limits, and farmer decision-making processes in upland northern Vietnam's sloping lands so that more relevant, slope-related policy suggestions can be formulated.

In areas with slopes greater than 15°, the Vietnamese state has strongly encouraged upland farmers to become sedentarized, with those living at higher altitudes tending to practice composite agriculture. This upland approach allows farmers to maintain a mix of permanent terraced rice paddy fields (or corn depending on localized rain fall and soil conditions), rotating swidden plots (officially banned), and small gardens, livestock, and the collection of forest products including fuel wood, herbal medicines, game, and honey, for subsistence or small-scale trade purposes (Kunstadter & Kunstadter, 1983; Leisz et al., 2005; Turner et al., 2015; Vuong, 2004). However, through their own initiatives, as well as due to state policies, upland households are becoming increasingly integrated into broader commercial commodity circuits through plantation forests, cash-crop programs, and a number of agricultural intensification practices. The latter includes state encouragement for farmers to use hybrid rice and maize seeds, along with chemical fertilizers and pesticides, that supplement or replace traditional rotating and organic supplies (Bonnin & Turner, 2012; Kyeyune & Turner, 2016). While the spatial impacts of some such changes can be monitored through quantitative analyses of LULC change maps, a number of the drivers and livelihood implications require on-the-ground interviews and observations. As such, the aim of this mixed-methods study is to investigate the relationships among sloping lands, LULC change, and local livelihoods in a remote, mountainous commune in northern Vietnam's borderlands, while taking into account state agricultural policies and changing livelihood needs.

2 Study area

Our case study site is Bản Phố commune (22^{0}33′16.97″N, 104^{0}16′07.12″E), Bắc Hà district, Lào Cai province (Fig. 1), chosen because it is fairly typical of rural communes in these uplands with regard to topography and livelihoods, with 74 percent of the territory sloped over 15° and differential marketplace access depending on which village one resides in (slope estimated by DEM; US Geological Survey online). Bản Phố commune covers 1666.56 hectares with an average altitude of 600-1000 m and a complex topography including a mountain range that decreases in height from the northeast to southwest. The average annual temperature for Bản Phố is 18.6 °C with a temperature range between 11.2 °C (January) and 23.8 °C (June and July), and an average precipitation of 1699.6 mm per year (Dang et al., 2016). In recent years, heavy rain-induced floods, landslides, drought (up to a month long), and very strong winds have become increasingly common during the summer months, while frost is increasingly a concern in winter. For example, in 2015, drought damaged 11.5 hectares of terraced wet rice in the commune (Bản Phố People's Committee (BPPC) 2015).

Bản Phố had a population of 3,515 individuals residing in 706 households in 2015, clustered in 13 villages (BPPC, 2015). The commune is located 3.2 km from the small district headtown of Bắc Hà (district population 62,413; Lào Cai Statistical Office (LCSO), 2018). Within Bản Phố commune, 99 percent of inhabitants are ethnic minority Hmong; the remaining one percent being Tày and La Chi ethnicities. Of the 706 households, 515 (73%) were classified as 'poor' (average monthly income per capita below 400,000 VND) in 2015 following government classifications based on Decision 09/2011/QĐ-TTg issued in 2011 (ignoring the fact that by undertaking composite, semi-subsistence livelihoods, a large part of each

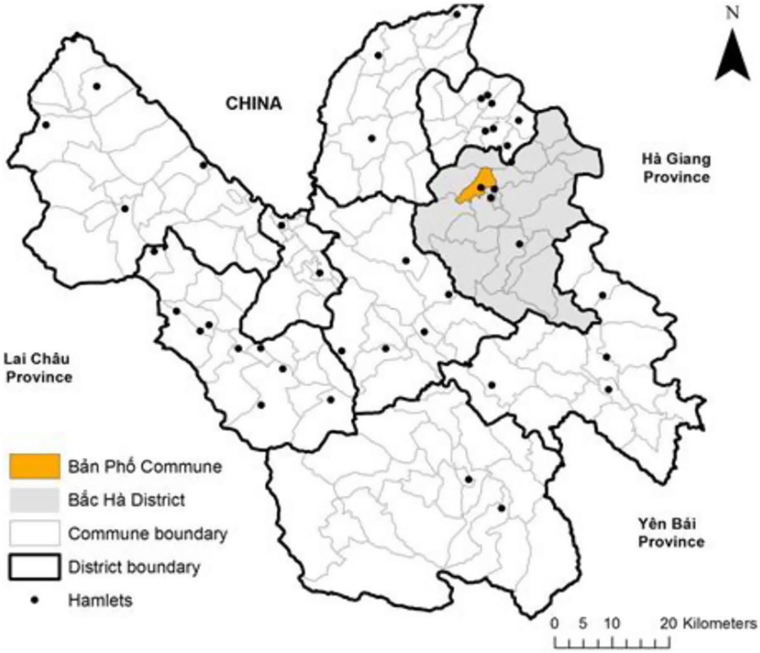

Fig. 1 Location of Bản Phố commune, Bắc Hà district, Lào Cai province (Vietnam)

households' labor goes toward subsistence agriculture, especially corn and rice). Corn is grown on 21 percent (360 ha) of the commune area, while terraced wet rice is grown on five percent (85 ha) (BPPC, 2015) (Fig. 2). More than 95 percent of corn and rice are now grown from hybrid seeds imported from China (interviews with communal officials, Bản Phố, October 2015 and August 2018), a practice that the state has been encouraging since the late 1990s in the northern uplands (Bonnin & Turner, 2012). Some other crops include beans (70 ha), peanuts (6.5 ha), and vegetables (49 ha). Plums (VN: *mận Tam-hoa*) and pear trees are planted on 86 ha, of which 35 ha are mature trees which produced 150 tons of fruit in 2015. Planted forests (159 ha) cover most of the remaining agricultural/forest land (BPPC, 2015). Most Hmong households in Bản Phố commune raise buffalo, horses, and pigs as livestock, which are an important source of household income, reaching about US$255,000 per year for the commune (BPPC, 2015). However, the commune is far better known across Vietnam for the distilling of maize alcohol (VN: *rượu ngô Bản Phố*). Hmong households here grow *hồng mi* shrubs on about 20 hectares of steep slopes to produce a natural alcohol yeast or starter which is widely praised for its quality (VN: *men rượu hồng mi*). In 2015, commune households produced over 510,300 L of maize alcohol, resulting in an income of approximately US$336,000 for the commune (BPPC, 2015).

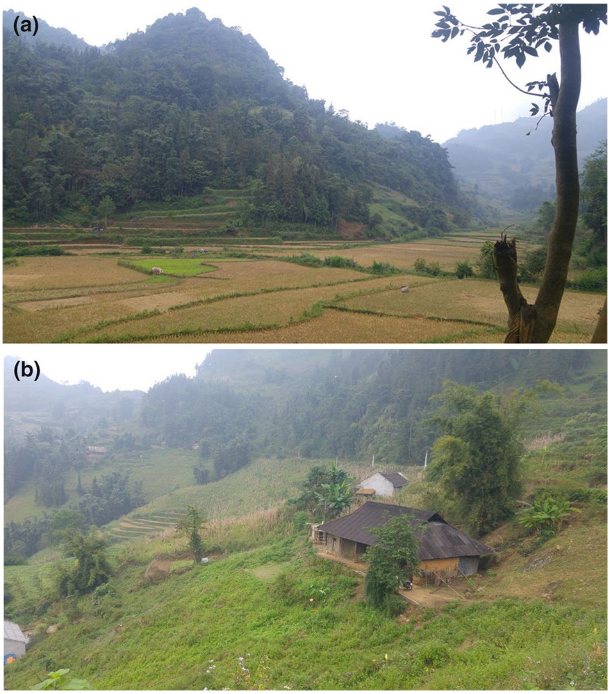

Fig. 2 **a** Total landscape and land-use land cover in Bản Phố commune, Bắc Hà district; Wet rice is grown on the plains and planted forests are grown on the slopes in the Phét Bủng 2 village **b** (photos by Nguyen, A.T., 2016)

3 Methods

Drawing on a mixed methods approach, we combined LULC change mapping with qualitative fieldwork to better understand the relationships among sloping lands, extreme weather events, agro-ecological conditions, and local ethnic minority livelihoods.

3.1 LULC change mapping

We created LULC change maps of Bản Phố commune from multispectral satellite imagery from SPOT 5 and 6 (Satellite Pour l'Observation de la Terre). Two SPOT 5 and one SPOT 6 images were obtained for the years 2007, 2010, and 2015, respectively (Table 1). All images were acquired in the winter when paddy rice, corn, and cassava are not present, allowing for the identification of subsistence crops as 'bare soil'. We identified four land cover classes (closed canopy forest, open canopy forest, shrubs, and bare soil) and a land use class (built-up), following Trincsi et al. (2014) and Turner and Pham (2015). Forests were separated by the FAO Land Cover Classification System: closed canopy covers more than 60–70 percent of a defined area, whereas open canopy covers between 10 and 20 percent and 60–70 percent (FAO, 2000: online). Water bodies were not considered in the classification because the streams in the commune are too narrow to be reliably classified from SPOT imagery.

Image pre-processing included: first, radiometric and atmospheric correction (López-Serrano et al., 2016); second, image fusion between multi-spectral bands with the panchromatic band through the Brovey transform method (Ghassemian, 2016; Jagalingam &

Table 1 SPOT satellite data specifications

Date	Sensor	Path-row	Image bands	Resolution
20/12/2007	SPOT-5	265–306	Pan (480–710 nm), Green (500–590 nm), Red (610–680 nm), Near IR (780–890 nm), SWIR (1,580–1,750 nm)	Pan (2.5 m from 2×5 m scenes), Pan (5 m, nadir), MS (10 m, nadir), SWIR (20 m, nadir)
17/01/2010	SPOT-5	266–305		
04/01/2015	SPOT-6	SEN_SPOT6_ 20150404_ 032627800_000	Blue (0.455–0.525 μm), Green (0.530–0.590 μm), Red (0.625–0.695 μm), Near-Infrared (0.760–0.890 μm)	Panchromatic (1.5 m), Multispectral (6.0 m—B,G,R,NIR)

Hegde, 2015); and third, image resampling to resize fused SPOT 6 imagery from 1.5 m to 2.5 m resolution (i.e., the same resolution as the fused SPOT 5 imagery). We then carried out an object-oriented classification with eCognition Developer 8.7® software consisting of segmentation, classification, and accuracy assessment (Avci & Sunar, 2015; Blaschke, 2010; Zhen et al., 2013). Multi-resolution segmentation algorithms were used with four parameters: spectral bands (for fused SPOT images), scale, color/shape ratio, and compactness/smoothness ratio. The segmentation parameters for the SPOT 5 imagery were for the pan-sharpened bands, scale: 100, color/sharp ratio: 0.8/0.2, and compactness/smoothness ratio: 0.5/0.5. Segmentation parameters for the three (SPOT 5) or four (SPOT 6) spectral bands (Blue, Green, Red, Near-Infrared), were scale: 120, color/sharp ratio:0.7/0.3, and compactness/smoothness ratio:0.5/0.5 for the SPOT 6 imagery. Classification of the image objects was based on rules composed of textural and spectral indicators for each class from 100 objects (segments) with ground observations. The classified images were validated to assess the accuracy of the LULC change maps with 102 ground reference points, which focused on typical LULC classes, collected in October 2016. We collected more ground reference points for built-up (24) and bare soil (34) as these are small and fragmented, making them more difficult to separate than forested areas, while we collected 11 and 17 ground reference points for closed canopy and open canopy, respectively. At each point, a GPS location was recorded (precision of 5 m), while land use was described and photos taken in the four cardinal directions. Table 2 shows a confusion matrix performed using the ground reference points. The average producer accuracy is 76.76 percent, with a range of values from 68.42 percent (open canopy) to 82.61 percent (built-up). The average user accuracy is 78.15 percent, varying from 75 percent (shrubs) to 82.35 percent (bare soil). The overall classification accuracy of the LULC is 77.45 percent.

LULC change was estimated from the object-based image classifications. The absolute values of changes for each class were estimated: area in hectares was computed in a specific time (2007, 2010, and 2015); area change in hectares was computed during periods (2007–2010, 2010–2015, and 2007–2015). The annual rate of change in hectares by year during 2010–2015 and 2007–2015 periods for each class was computed to measure LULC change by following equation (Puyravaud, 2003):

$$\text{Rate} = \frac{\ln(A_2/A_1)}{t_1 - t_2}$$

where A_1 = arable land cover at an initial time (t_1); A = arable land cover at a later time (t_2).

3.2 Qualitative interviews and observations

In October 2016, 50 farmers from households in all 13 villages in Bản Phố commune were interviewed, using a semi-structured interview guide. Households were selected using a systematic random sampling approach to provide an even coverage of the commune's population within the sampling frame. Each household was considered a sampling unit (with either a male or female adult who was at home and knew about the household's livelihoods being interviewed). Interviews lastest about two hours and were complemented by observations and slope measurements. The semi-structured interview guide covered themes such as sloping land area and use, crops, forestry, livestock, alcohol production, changes in crops over time, agricultural inputs, pressures on land, external inputs to livelihoods, local indigenous knowledge, policy impacts, and conditions of house and other personal property (as a proxy for wealth). The interviews yielded both descriptive statistics and qualitative data.

Table 2 Confusion matrix for accuracy assessment of the 2015 land use classification

	Ground reference					Total
	Closed canopy	Open canopy	Shrubs	Bare soil	Built-up	
Classification						
Closed canopy	7	0	2	0	0	9
Open canopy	2	13	1	1	2	19
Shrubs	0	1	12	2	1	16
Bare soil	2	2	1	28	2	35
Built-up	0	1	0	3	19	23
Total	11	17	16	34	24	102
User accuracy (%)	77.78	76.47	75.00	82.35	79.17	78.15%
Producer accuracy (%)	77.78	68.42	75.00	80.00	82.61	76.76%
Overall accuracy (%)						77.45%

The qualitative data were coded using thematic coding (Bryman, 2015). We also met with government officials of Bản Phố commune to collect statistical data, and other relevant documents and policies including details regarding the New Rural Development Program conducted for the commune for the period 2010–2020. These data are supported by observations during fieldwork with ethnic minority farmers in the province since 1999.

4 Results

4.1 LULC change during 2007–2015

LULC change in Bản Phố commune from 2007 to 2015 is characterized by a variability of agricultural land use, deforestation, afforestation, and urban expansion. Table 3 shows that in 2015 bare soil (agricultural lands) covers the largest area (539.22 ha), with open canopy next (433.31 ha) and then shrubs (313.26 ha), while built-up (153.44 ha) and closed canopy (123.88) covered the smallest surface areas.

The main increases in a specific land cover or land use were of shrubs (117.49 ha during 2007–2010 and 42.79 ha during 2010–2015), of built-up areas (34.94 ha during 2007–2010 and 18.89 ha during 2010–2015), and of open canopy (47.04 ha during 2007–2010 and 88.62 ha during 2010–2015). The main decreases were of bare soil (95.99 ha during 2007–2010 and 142.43 ha during 2010–2015), and closed canopy (103.48 ha during 2007–2010 and 7.87 ha during 2010–2015). For 8 years, shrubs have had the biggest increase of area (160.28 ha) with the annual rate of change of 8.96 percent, whereas bare soil (agricultural land) has had the biggest decrease in area (238.42 ha) with an annual rate of change of 4.58 percent.

4.2 Land use land cover transition 2007–2015

LULC transition matrices (Tables 4 and 5) indicate the observable transitions for shrubs, built-up area, and open canopy during the period 2007–2015. During 2007–2010, transitions to shrubs occurred most often when bare soil converted to shrubs (124.41 ha), while built-up areas were converted mainly from bare soil (87.48 ha). Open canopy was converted primarily from bare soil and closed canopy (114.67 ha and 80.48 ha, respectively). Although bare soil was reduced, a substantial area of shrubs and open canopy converted to bare soil as well (63.75 ha and 92.53 ha, respectively). LULC change during 2010–2015 shows the same trend. Bare soil converted to shrubs (149.63 ha), while built-up was mainly converted from bare soil (72.74 ha). The expansion of open canopy occurred most often due to a conversion from bare soil (161.16 ha). A substantial area of shrubs and open canopy converted to bare soil (95.05 ha and 90.12 ha, respectively).

The spatial patterns detectable in the LULC change maps show that the total landscape has become more fragmented since 2007. In 2015, the built-up areas and shrubs were distributed along the roads and in the central parts of villages (Fig. 3). The southwestern part of Bản Phố commune saw an important decrease in closed canopy. The most significant increase of built-up areas and shrubs can be seen in the northeast and southwest parts of commune, especially in Lang Moi, and Phec Bung 1 & 2 villages. A decrease in bare soil was noted in both central and northeastern parts of Bản Phố commune. The LULC change patterns were linked to slope, with the main LULC changes having occurred on sloping lands over 15 percent. These sloping lands witnessed the highest increase in shrubs

Table 3 LULCC change in Bản Phố commune from 2007 to 2015 (hectares)

LULC	Area in 2007 (ha)	Area in 2010 (ha)	Area in 2015 (ha)	2010–2007 area change (ha)	2015–2010 area change (ha)	2015–2007 area change (ha)	2010–2007 annual rate of change ($\%y^{-1}$)	2015–2010 annual rate of change ($\%\ y^{-1}$)	2015–2007 annual rate of change ($\%y^{-1}$)
Shrubs	152.98	270.47	313.26	117.49	42.79	160.28	19.00	2.94	8.96
Bare soil	777.64	681.65	539.22	− 95.99	− 142.43	− 238.42	− 4.39	− 4.69	− 4.58
Built-up	99.61	134.55	153.44	34.94	18.89	53.83	10.02	2.63	5.40
Closed canopy	235.23	131.75	123.88	− 103.48	− 7.87	− 111.35	− 19.32	− 1.23	− 8.02
Open canopy	297.65	344.69	433.31	47.04	88.62	135.66	4.89	4.58	4.69
Total	1563.11	1563.11	1563.11	0	0	0	0.00	0.00	0.00

Table 4 LULCC transition in Bản Phố commune from 2007 to 2010 (hectares)

Year	In 2010						
	LULC	Shrubs	Bare soil	Built-up	Closed canopy	Open canopy	Total
In 2007	Shrubs	33.25	63.75	11.73	11.21	33.04	152.98
	Bare soil	124.41	431.88	87.48	19.2	114.67	777.64
	Built-up	14.34	40.87	20.88	5.68	17.84	99.61
	Closed canopy	37.82	52.61	1.84	62.48	80.48	235.23
	Open canopy	60.23	92.53	12.92	33.13	98.84	297.65
	Total	270.05	681.64	134.85	131.7	344.87	1563.11

Table 5 LULCC transition in Bản Phố commune from 2010 to 2015 (hectares)

Year	In 2015						
	LULC	Shrubs	Bare soil	Built-up	Closed canopy	Open canopy	Total
In 2010	Shrubs	45.33	95.05	26.96	16.56	86.57	270.47
	Bare soil	149.63	265.75	72.74	32.37	161.16	681.65
	Built-up	27.65	56.37	18.98	4.55	27	134.55
	Closed canopy	26.42	31.93	11.83	19.76	41.81	131.75
	Open canopy	64.23	90.12	22.93	50.64	116.77	344.69
	Total	313.26	539.22	153.44	123.88	433.31	1,563.11

(114.7 ha), and the highest decrease in bare soil (160.91 ha) and closed canopy (84.39) (Tables 6, 7 and 8). How these situations might have occurred and their implications are reflected upon in Sect. 4.3.

4.3 LULC change drivers and the consequences for local livelihoods

To gain a better understanding of the drivers of these LULC changes, the consequences for local livelihoods, and how these related to both physical sloping lands and farmer understandings of sloping lands, we first needed to know how farmers defined this type of land. Interviewees were asked to define 'sloping land' in their own terms to gain an emic perspective, which was then thematically coded (Fig. 4). All 50 farmers categorized some or all of their land as being 'steeply sloping'. The majority of initial responses (46%) focused on topographic features, noting that sloping land is any land discernible to the eye as having an important incline. During interviews, farmers often physically pointed to what they determined was an example nearby, adding comments such as: "Like here, it's mountainous, there are lots of hills and slopes." In all cases where access was possible, such comments were then confirmed by using a geological compass to determine that the slope was over 15°. Fourteen percent of interviewees gave responses directly linked to their ability to farm the land, citing that steeply sloping lands are where buffalo, horses, or mechanized plows cannot be used for cultivation. They also noted that steep slopes meant "there is lots of shallow soil, rocks and the soil is not fertile" and that one "cannot grow wet rice" there. Others added that "it is difficult

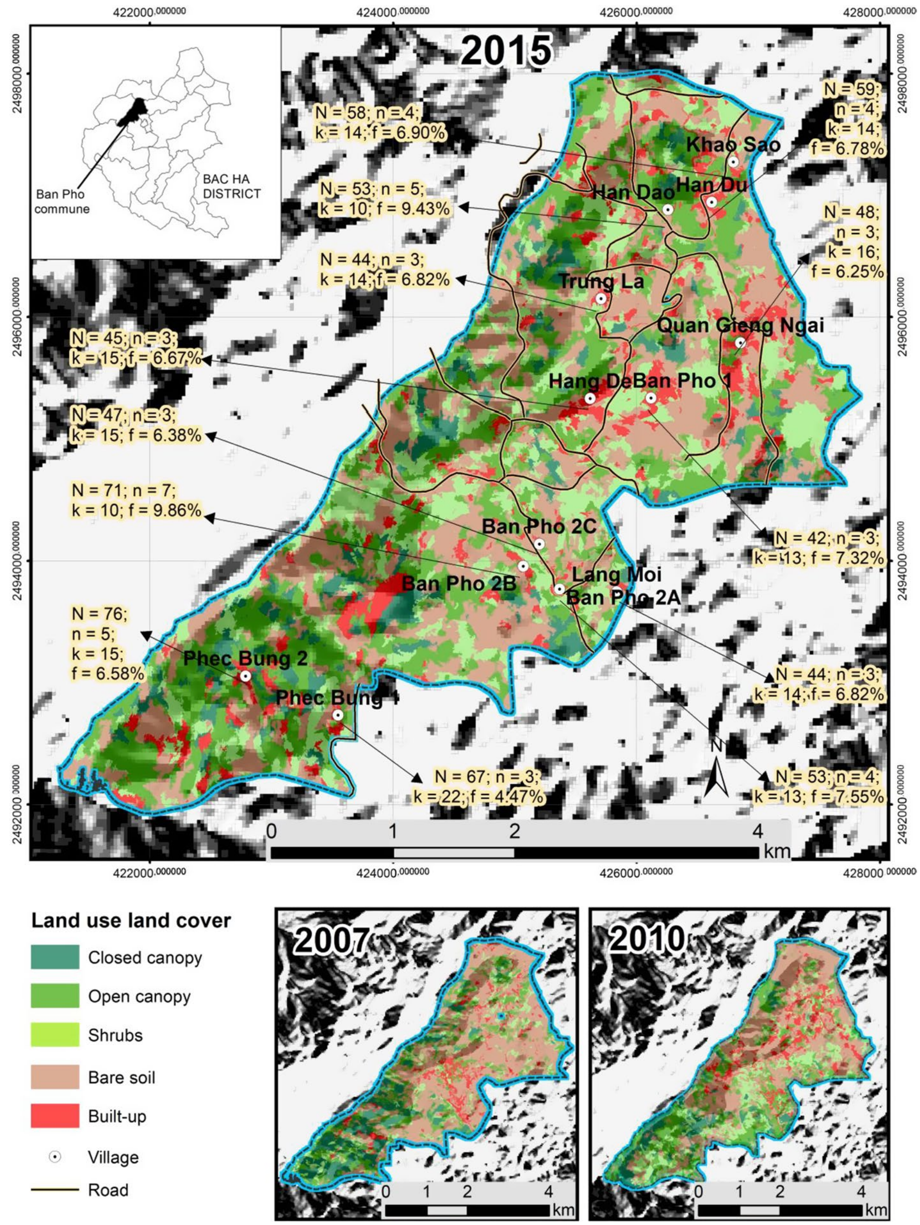

Fig. 3 LUCC maps of Bản Phố mountain in 2007, 2010, and 2015. (where: N = population size; n = desired sample size; k = sampling interval; f = sample faction)

to grow and take care of crops" on such land, "only a few trees can grow" there, and "it is land that erodes often and has landslides." Eleven percent focused on physical access, noting that steeply sloping lands means motorbike access is arduous and "it is difficult for walking." With these definitions in mind, we now focus on determining the drivers and livelihood consequences of three main findings from our LULC analysis, namely an

Table 6 LULCC transition in sloping land (> 15%) in Bản Phố commune from 2007 to 2015 (hectares)

Year	In 2015						
	LULC	Shrubs	Bare soil	Built-up	Closed canopy	Open canopy	Total
In 2007	Shrubs	18.19	35.5	7.37	7.51	40.38	108.95
	Bare soil	120.71	249.09	63.56	22.08	109.57	565.01
	Built-up	17.3	24.32	8.94	5.08	20.89	76.53
	Closed canopy	31.03	42.62	19.14	28.90	60.92	182.61
	Open canopy	36.42	52.57	15.04	34.65	86.95	225.63
	Total	223.65	404.1	114.05	98.22	318.71	1158.73

Table 7 LULCC transition in plains (< 15%) in Bản Phố commune from 2007 to 2015 (hectares)

Year	In 2015						
	LULC	Shrubs	Bare soil	Built-up	Closed canopy	Open canopy	Total
In 2007	Shrubs	6.79	15.8	1.85	2.05	17.72	44.21
	Bare soil	53.41	81.84	25.53	6.11	47.66	214.55
	Built-up	5.93	6.56	3.82	0.92	5.67	22.9
	Closed canopy	8.01	15.48	4.24	8.16	15.63	51.52
	Open canopy	13.76	17.95	3.48	8.70	27.31	71.2
	Total	87.9	137.63	38.92	25.94	113.99	404.38

increase of ‘shrubs’ on sloped land, specific pockets of conversion to ‘bare soils’, and an increase in urban areas in a particular locale.

Fifty-one percent of the 50 farmers interviewed in the commune grow some variety of trees for commercial purposes. Pine is the most frequent choice (38%), with farmers pointing out multiple benefits including the cash they can obtain from selling the pine resin, being able to use the wood for their own needs, and the suitability for their sloping lands (Fig. 5). As one farmer who previously grew corn on his sloped land before switching to pine explained: “Over time my corn had reduced productivity, so I switched to growing pine. It is much easier”, while another added: “The government gave me free [pine] seedlings, so I am trying it; it is hard work farming these slopes.”

Thirty-two percent of the farmers were growing plum trees, with over 50 percent of these farmers stating that they harvested approximately 100 kilos a year. When asked why they chose to cultivate this tree species, farmers explained that it helps to “provide a stable income”, although it was also interesting to note that a few complained that “selling plums had high value a few years ago, but now I cannot sell them.” This has been confirmed by other livelihood studies in the region that note a saturation of the market for plums, after an international NGO encouraged farmers in the province to start growing the trees in the late 1990s (Turner et al., 2015). Farmers also remarked on the difficulties planting or maintaining trees on their sloping land, with 53 percent of those growing trees commenting on the struggle to care for the trees and their low survival rate. They also noted the ongoing difficulties of physically accessing their land parcels and the low productivity of these crops. Given the short funding cycles of many NGO activities in these uplands that we

Table 8 Comparing LULC transitions in sloping lands and plains during 2007–2015 (hectares)

LULCC	Sloping lands (> 15%)				Plains (< 15%)			
	Area in 2007 (ha)	Area in 2015 (ha)	2015–2007 area change (ha)	2015–2007 annual rate of change (%y^{-1})	Area in 2007 (ha)	Area in 2015 (ha)	2015–2007 area change (ha)	2015–2007 annual rate of change (%y^{-1})
Shrubs	108.95	223.65	114.70	8.99	44.21	87.90	43.69	8.59
Bare soil	565.01	404.10	− 160.91	− 4.19	214.55	137.63	− 76.92	− 5.55
Built-up	76.53	114.05	37.52	4.99	22.90	38.92	16.02	6.63
Closed canopy	182.61	98.22	− 84.39	− 7.75	51.52	25.94	− 25.58	− 8.58
Open canopy	225.63	318.71	93.08	4.32	71.20	113.99	42.79	5.88
Total	1158.73	1158.73	0.00		404.38	404.38	0.00	

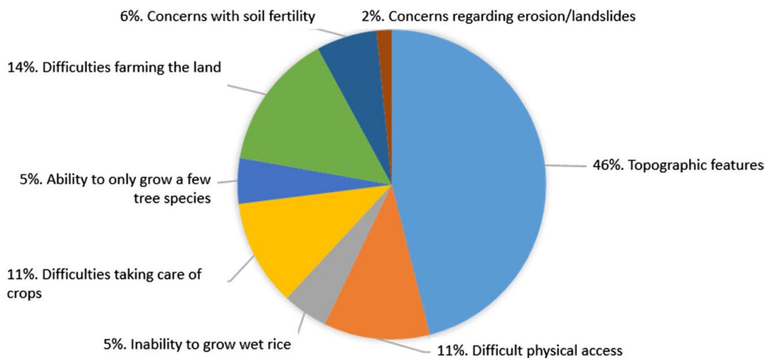

Fig. 4 Key elements that farmers discussed when defining sloping lands

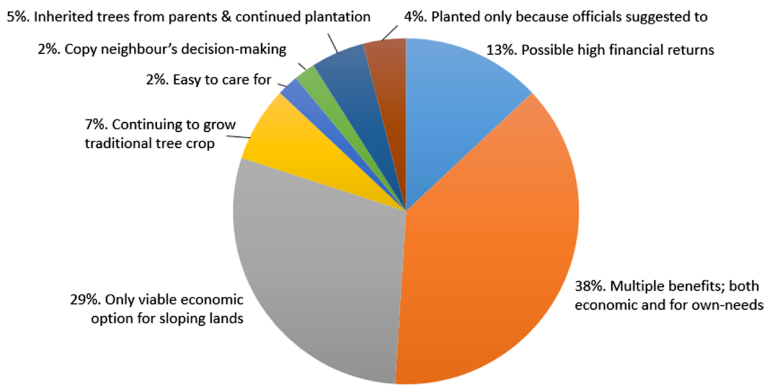

Fig. 5 Farmer's rationales regarding why they planted trees on sloping land

have encountered over the past twenty years, this mismatch does not surprise us, but it is clearly an ongoing concern if upland farmers are to receive appropriate outside interventions and support.

Changing weather patterns are also causing farmers to rethink the crops that they plant. Of the 50 farmers interviewed, 54 percent reported having experienced a water shortage or drought during the last ten years, with 2013 and 2015 being remembered as particularly bad years. Of those farmers, 85 percent noted that the droughts damaged crops or severely reduced productivity, especially for wet rice and corn, with some remarking "the rice just did not grow." Farmers estimated having lost between 30 and 50 percent of their corn and wet rice due to drought. These events are causing farmers to consider alternative crops, resulting in a decline in their self-sufficiency as they shift toward cash-cropping options instead.

While a *decrease* in bare soil has occurred in both the central and northeastern parts of Bản Phố commune, largely attributed to an increase in built-up areas (see below), there was also a substantial area of shrubs and open canopy converted to bare soil. When asked, officials and farmers both noted that this is because more corn is being grown due to rising demand for homemade, ethnic minority distilled alcohols, especially from lowland Vietnamese (see also Thanh Nien, 2016). Interestingly, all the Hmong households making corn alcohol (90% of those interviewed) said that their corn was grown on sloping land. Often the majority of family members are involved, and 65 percent of these households sell their home-distilled alcohol at the Bắc Hà Sunday market. These farmers noted that they were using hybrid corn seeds for this alcohol, arguing that it had a shorter harvest period, was suitable for sloping land, or because it was more resistant to extreme weather and pests in the area. Further, farmers also mentioned that “traditional corn plants have high stalks, so they fall down easily during big winds and heavy rainfalls” while “hybrid corn is shorter, so it does not fall, but it does not taste nearly as good. So we just use it for alcohol, not to eat.” Farmers commented that what makes their alcohol unique is the natural alcohol yeast *hồng mi*, that Hmong households grow on the steep slopes in Bắc Hà district, following traditional ecological knowledge passed down through generations, as well as the pureness of local water sources.

5 Discussion

5.1 LULC change on sloping lands—state encouragement and drought impacts

Our LULC analysis showed that the main LULC changes in Bản Phố commune have occurred in areas with slopes over 15°. While the LULC change maps indicated that the largest conversion on sloped land was to shrubs from bare soil (that is from land used for annual crops such as rice or corn), on-the-ground observations were able to reveal that this ‘shrub’ vegetation is most commonly young pine and fruit tree plantations. This is occurring partly due to government encouragement for farmers to convert former rotational swidden land (including corn and dry/hill rice) to cash-crops. Farmers receive pine tree seedlings from forestry officers either free (if officially categorized as poor) or at a subsidized rate. Some grow pine trees to tap for resin (used in paint amongst other products), while others focus on timber as a long-term investment. Plum and pear tree cultivation are also being strongly encouraged by state officials, with all such moves to cash-cropping supported by the New Rural Development Program. We also observed an increase in *Hồng mi* shrubs, which are processed following Hmong traditional ecological knowledge to make a fermentation agent to produce Bản Phố alcohol, discussed further below. Farmers explained that they are experimenting with cash-cropping not only because of state encouragement and incentives, but because of their increasing needs for cash. As introduced earlier, this includes purchasing hybrid maize and rice seeds that need to be bought annually, along with chemical fertilizers and pesticides, instead of relying on seeds from previous harvests as they could do with land-race varieties supported with organic, home-mixed fertilizers. Other rising costs such as school fees, health care, and increasing access to different consumption goods are also all driving this move toward increasing cash-cropping (see also Bonnin & Turner, 2012; Kyeyune & Turner, 2016).

5.2 Specific pockets of conversion to bare soils—the role of alcohol

The increasing commercialization of upland ethnic minority distilled alcohol as a niche product is being strongly supported by the Vietnamese state. This home-produced alcohol has attracted the attention of provincial officials as a possible ‘Geographical Indication’ (GI), considered “an important tool for socio-economic development in the country” (Pick et al., 2017: 305; interviews 2018). While the overall number of GIs in the country remains fairly limited, the state has embraced this approach, and while this specific initiative is still in its early days, production is being encouraged for future possible expansion. Concurrently, Kinh (lowland Vietnamese) and Western entrepreneurs are also ‘jumping on the band-wagon’, seeing this as a promising private business opportunity (Po et al., 2020), with low-land traders visiting Bắc Hà Sunday market to test and buy sizable quantities of Bản Phố alcohol.

5.3 Increasing built-up areas—the drive to make a city

The LULC change maps revealed that built-up areas were increasing in the northeast and southwest areas of the commune. During field observations, it was clear that built-up areas in the northeast were increasing along provincial road DT159, which connects Bắc Hà town with Si Ma Cai district. Directly on the Vietnam-Chinese border, Si Ma Cai district was part of Bắc Hà district until 2000, and since 2016 has been part of the ‘Lao Cai Border Gate Economic Zone’, a state initiative that hopes to attract more investment and traffic to this area (Voice of Vietnam 2016). The built-up areas along road DT159 in Bản Phố commune were mostly small shops and services such as food stalls and sundry shops, motorbike repair shops, and a few official offices. The increase in built-up area in the southwest appears to be linked more to natural population increase in the area, along a small road that runs northwest to southeast across the southern third of the commune.

It is also interesting to note that officials explained that the ‘Socio-economic Master Planning for Bắc Hà District until 2020’ states that the urban area of Bắc Hà town will be expanded by merging Bắc Hà town area and specific regions of four neighboring communes (Bắc Hà People’s Committee (BHPC), 2015). The northeast and southeast/central areas of Bản Phố are part of this planned merger. This merger did not occur in 2020 as outlined in the Plan; however, it is a priority for the period 2020–2025. After the merger, Bắc Hà town will be upgraded to city status. As Henein et al. (2019) explain, Vietnam’s socialist planning approach means that since 1990 urban areas have been divided into five classes as well as ‘Special Cities’, based on criteria such as population size and density, the proportion of non-agricultural activities, and other factors. District and provincial authorities want Bắc Hà town upgraded as this results in greater financial support, as well as central government approval (Kienviet, 2014). This also helps district officials to secure their positions for another term.

6 Conclusions

Located in the Sino-Vietnamese borderlands, in an extremely rugged and mountainous terrain, ethnic minority farmers make do and innovate with the best options available to them. Of the new schemes and seeds that reach them, pine, plum, and pear trees have become cash-cropping options that provide new opportunities for their sloping farmlands. With many of these tree crops still in their infancy in Bản Phố commune, it is too early to note how this switch from semi-subsistence agriculture with a focus on rice and corn, to far greater degrees of cash-cropping will impact local livelihoods. If droughts continue, it might be that this switch has been a wise move. However, if there are future problems with these new cash-raising options, such as pests or market saturation, as has already occurred for plums, then income and hence food security might not see important improvements.

At the same time, these borderlands are becoming increasingly connected to the outside world. To the west of Bắc Hà district lies a new highway completed in 2014 connecting Hanoi to the Sino-Vietnamese border city and provincial capital of Lào Cai. Thirty kilometers to the west again lies Sa Pa town, a rapidly expanding tourist destination for Kinh. Now congested with traffic on weekends, a number of international tourists are bypassing Sa Pa and starting upland tours of the north from Bắc Hà town instead. If this trend continues, along with Bắc Hà town's upgrade, it would be reasonable to suggest that the built-up areas in current day Bản Phố commune are set to expand in the near future. This could intensify demand for local commodities such as home-made alcohols, but might also increase land prices in Bắc Hà town's hinterlands that could cause some farmers to decide to sell their land, with unforeseen long-term livelihood implications.

As found by Garrard et al. (2016: 308) in their study of LULC change in eastern Nepal, many of the LULC changes we observed "are occurring at fine spatial scales that satellite imagery is not able to access. This underscores the importance of triangulation and reconciliation of findings obtained from different research approaches". Likewise, this mixed-methods case study has shown that farmers in this remote mountainous area are having to make important livelihood decisions regarding LULC change drivers ranging from increasing weather extremes, to changing market opportunities, to urban planning policies. Farmers are careful to take into account their long-established knowledge of the difficulties when farming sloping land, but are also willing to try out new opportunities. Nonetheless, to what degree state encouragement to switch to cash-crops, coupled with extreme weather events such as increasing droughts, will cause future food insecurity is not yet known. But it is a concern that these interrelated dynamics were not mentioned by any local officials. While we recommend that careful, ongoing monitoring of the situation is needed, we are also worried that this could fall onto the shoulders of ethnic minority farmers themselves and fail to be a priority for local officials who might set their sights on the potential rewards from nearby Bắc Hà town gaining city status instead.

Taking a step back, this study has highlighted the importance of understanding the local decision-making processes that upland farmers make, the complexities of state interventions when they are 'rolled-out' on the ground, the degree to which farmers decide to engage with such interventions, and the ways by which (increasing numbers of) extreme weather events can influence and interact with the former. If policy makers in the Global South wish to create sound interventions to support farmers with sloping lands it becomes clear that such multi-faceted variables—and others depending on the local context—must be carefully analyzed and interpreted and that a LULC change analysis by itself cannot provide the requisite evidence. Together however, we believe that a LULC change study *and* carefully formulated qualitative interview questions that build on evidence supplied by the former, can support more appropriate, slope-related livelihood policy options.

Acknowledgements The authors would like to thank all the household members, and district and commune authorities, who collaborated in this research for their knowledge and time. We also thank Kate Trincsi and Madeleine Hykes for valuable research assistance. This study is in partial fulfillment of the Vietnam project NAFOSTED 105.07-2015.04. Partial funding also comes from the Social Science and Humanities Research Council, Canada.

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