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Why do farmers still grow corn on steep slopes in northwest Vietnam?

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Abstract Intense cultivation of annual crops on steep slopes in northwest Vietnam has resulted in widespread and severe erosion. This has led to myriad problems including siltation of dams critical for hydroelectricity generation, and increasing levels of rural poverty due to declining crop yields. The solution to these problems is sustainable land management, in particular sloping land agricultural technologies. Our study focuses on defining, and finding solutions to, a second-order problem: that farmers are reluctant to adopt sustainable land management practices, despite numerous projects demonstrating their effectiveness. Interviews with farmers in northwest Vietnam confirmed that intense corn cultivation on steep slopes provided the majority of income for most households. The financial security associated with growing corn (compared to alternative crops) was the deciding factor in land management choices. However, interviews also revealed that farmers were dissatisfied with growing corn because of low income and high input costs. Farmers' replies indicated that they thought they had no alternative to growing corn. However, farmers were aware of alternative crops, and were particularly interested in growing grass, fruit trees and timber trees, although few farmers were keen to be first to adopt these alternative species extensively. Further research is required on development of production-to-commercialization chains for alternative crops, and more generally, to find ways to increase farmer financial security during transition to sustainable land management.

Keywords Agroforestry · Maize (*Zea mays*) · Steep slopes (syn. sloping lands, steep lands, uplands, mountainous areas) · Son La · Van Ho

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Introduction

Land degradation in the Asia–Pacific region is being driven by a combination of increasing population and limited land resources, which result in land shortage

and poverty, and lead to unsustainable land management (FAO 1995). In particular, this manifests in the cultivation of steep slopes, resulting in erosion (Millennium Ecosystem Assessment 2005; Cramb et al. 2007). Erosion causes decreased soil fertility, lowers water quality, increases siltation of streams and dams, and heightens the risk of flooding (Lal 1998). Clearing forests and replacing them with crops also increases landslide potential (Sidle et al. 2006), and cumulative soil erosion after forest clearing can cause long-term damage, reducing soil water storage opportunity, affecting the potential of future remediation (Bruijnzeel 2004). It is widely accepted that growing crops that are likely to cause erosion, particularly corn and cassava, should be avoided on steep slopes (Valentin et al. 2008).

Vietnam's corn production has been increasing since the 1970s, and has increased steeply since 1990 with government support for hybrid maize (Thanh Ha et al. 2004a, b; Kiel et al. 2008). There has been a global increase in demand for corn as animal feed (Kiel et al. 2008; Karimov et al. 2016). However, corn is also a food source for some ethnic minority groups in Vietnam (i.e., Hmong; Kyeyune and Turner 2016). In Vietnam, most corn is grown in the north as a monoculture on upper slopes (Thanh Ha et al. 2004a; Kiel et al. 2008; Hoang et al. 2013). The effects of soil erosion in Vietnam are well documented, and include: decreased soil fertility (Wezel et al. 2002; Nguyen et al. 2008; Haring et al. 2014), flooding (Schad et al. 2012) and decreased crop yields (Clement and Amezaga 2008; Hoang et al. 2013). Paradoxically, a strengthening of forest protection, via the 'Law on Forest Protection and Development 1991', and consequent reduction of swidden agriculture has resulted in further uptake of corn cultivation (including on illegally cleared areas), as sedentary agriculture is promoted (Knudsen and Mertz 2015). A further serious environmental problem is siltation of the rivers and dams in the catchments of two major rivers, the Hong and Da rivers, in northern Vietnam. The Da River alone produces almost 50% of Vietnam's hydropower (IHA 2014), and impacts on hydropower generation from these rivers are felt widely. Forest clearing, soil erosion and declining crop yield, each of which can each be linked to intensive corn cultivation on steep slopes, are emerging as major environmental and economic problems in northern Vietnam.

There are agricultural (and agroforestry) technologies that have been specifically designed to reduce soil erosion on hillsides, while maintaining farmer livelihoods. These are often referred to by the acronym SALT (Sloping Lands Agricultural Technology; Tacio 1993). On slopes, the aim of SALT is to reduce the erosive power of overland water flow and increase infiltration, consequently reducing soil erosion and increasing the sustainability of the cropping system. SALT systems often involve contouring, mulching and planting of perennial species, for example, planting nitrogen-fixing trees on contours and lopping their crowns periodically to provide mulch in inter-row (hedgerow-intercropping) and, or planting fruit trees and, or grass strips. Evidence of the efficacy of SALT to reduce erosion, and maintain soil fertility, is well reported (e.g., Bruijnzeel 2004; Delgado and Canters 2012; Hernandez et al. 2012, for the Philippines; Lamichhane 2012, for Nepal; Htwe et al. 2015, for Myanmar; Li et al. 2015, for China). Successful outcomes resulting from farmers' adoption of SALT in these countries indicate that SALT technology may be useful in northwest Vietnam.

Our study was undertaken to find out why farmers still grow corn on steep slopes in northwest Vietnam, despite numerous projects promoting more sustainable crops and practices. In the following sections of this paper, we describe our methods (i.e., a literature review of previous land management projects in northwest Vietnam, and a survey of six villages in northwest Vietnam). We then present the results of the interviews and discuss the implications of our results for future projects that aim to increase land management sustainability.

Methods

Study area

Northwest Vietnam covers an area 2.8 million hectares and is composed of four provinces; Son La, Dien Bien, Lai Chau and Lao Cai. The area is hilly to mountainous, and the majority of land (60%) has slopes at 15 degrees or greater (Staal 2014). Annual rainfall ranges from 1200 to 2800 mm across the area, and is seasonal, with most of the rain falling approximately from June to September. Northwest Vietnam is one of Vietnam's poorest regions (Tuyen et al. 2015), and the

large ethnic minority population is particularly poor, with 73% of the ethnic minority population living below the poverty line (World Bank 2012).

Van Ho, the study area for this research, is a new district within Son La province, northwest Vietnam (Fig. 1). Van Ho was divided from Moc Chau in the 2014 because of its growing population. Ethnic minorities dominate the population of Van Ho; particularly Dao, Hmong, Muong and Thai (Van Ho Agriculture Sector 2015), and in 2014, 54% of households were classified as being poor (Van Ho District 2016). The area of Van Ho is 97,984 ha. Of this, around 20% is classed as agricultural land (19,946 ha), and almost all agricultural land is classed as sloping (17,290 ha) (Van Ho District 2016). The most common agricultural crops by area are corn (maize), winter rice, tea, rubber, upland rice, arrowroot and cassava (Van Ho Agriculture Sector 2015). Forest is estimated to cover 52% of Van Ho (51,128 ha). The forest area is classified as 'special use' (26%, including national parks, nature conservation areas and research forests), protection (48%, including forests managed to protect water catchments) and production forest (26%, including forest managed for timber production, mainly plantations).

Study design

Part 1: undertaking a literature review of previous projects

We undertook a desktop review of the literature on land management projects in northern Vietnam, relating to clearing forest on steep slopes for corn cultivation, and the problem of erosion. We used Google, Google Scholar and Scopus for the following word searches in March 2017: Vietnam + sloping/steep/upland/mountainous + erosion + corn/maize ± forest. We assessed the first 40 results from each source, aiming to provide a snapshot of the projects undertaken, rather than an exhaustive list. Projects were included only if they had been active in northwest Vietnam, and if their objectives and results were clearly expressed. We focused on recent research (i.e., from 2000 to present), mainly due to the availability of online documentation. The two main types of literature described: (i) current and past conditions (including surveys about current beliefs) or (ii) on new and, or uncommon management approaches, usually field trials, experiments, modelling or case studies.

Part 2: interviews with farmers

We interviewed 60 households about their views on corn and alternative crops (i.e., crops other than corn and rice). In Van Ho district, we selected three communes, based on the prevalence of corn cultivation: Suoi Bang, Chieng Khoa and Van Ho. We used a sampling framework of 10 households in each of six villages, with two villages from each of three communes (Table 1). We used the Vietnamese Government's poverty scale (which is based on average household income; Vietnam Government 2011, 2012, 2014), to select villages and households so that our interviews captured the responses of farmers from a range of economic levels.

In each household we undertook a semi-structured interview which included questions about the number of people in the family, how much corn was produced in 2015, where farmers purchased their seed and fertiliser, and how much herbicide they used, crops (other than corn) which were grown and numbers of livestock. Farmers were also asked why they grew corn, the benefits and drawbacks of growing corn, if they knew of or had tried any species other than corn, and their thoughts on the benefits and drawbacks of these alternative crops. We acknowledge that land management can be improved by using soil conservation methods (including in corn cultivation), such as contour planting, mulching and no/minimum tilling. Because farmers were relatively consistent in their methods of growing corn, including soil management, we focus instead on varying attitudes to alternative crops.

To ensure the reliability and validity of farmers' responses, we used an interview team which, in addition to the Australian researcher, included two Vietnamese nationals, one of whom lives in a town adjacent to Van Ho. Farmers' verbal responses were noted by both Vietnamese interviewers and cross-checked for consistency.

Linear regression (using R software; R Core Team 2016) was used to analyse the relationship between fertilizer application and corn production.

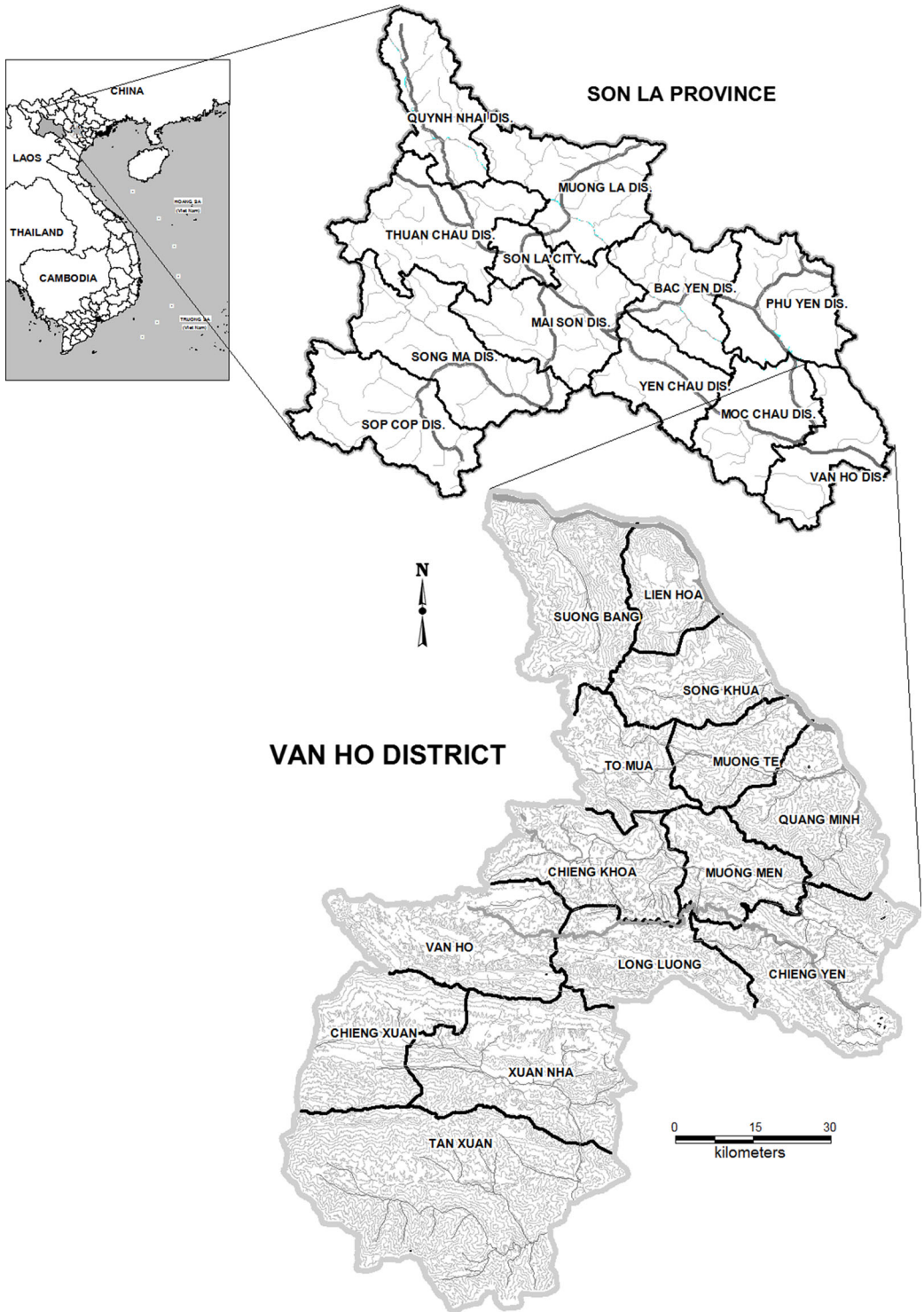

Fig. 1 Map of the study location in Van Ho district, within Son La province, in northwestern Vietnam

Table 1 Villages, their poverty ratings, ethnic groups and household information

Commune	Commune poverty	Village	Ethnic group	Mean number of adults (±SD)	Village poverty	Corn % income	Area of paddy rice (ha) (±SD)	Number cattle (±SD)	Number buffalo (±SD)
Suoi Bang	Level 3 (poor)	Khoang Phieng	Muong	3.2 ± 1.6	No difficulties	52	312 (±242/77%)	2.9 ± 1.6	0.7 ± 0.8
		Pua Lai	Muong, Thai	2.6 ± 0.9	No difficulties	50	620 (±585/94%)	1.7 ± 2.4	0.6 ± 0.7
Chieng Khoa	Level 2 (intermediate)	Pang 1 and 2	Thai	3.7 ± 1.2	Difficulties	52	1272 (±907/71%)	4.7 ± 9.5	1.7 ± 1.7
		Chieng Le	Muong, Thai	3 ± 1.2	Difficulties	60	2475 (±2222/90%)	1.8 ± 1.3	1.2 ± 0.6
Van Ho	Level 2 (intermediate)	Pa Cop	H'Mong	3.9 ± 1.4	Most difficult	50	778 (±1121/144%)	1.9 ± 3.2	0.3 ± 0.5
		Suoi Lin	Dao	3.5 ± 0.8	No difficulties	63	1500 (±820/54%)	1.3 ± 1.7	1 ± 1.1

Results

Part 1: literature review of previous projects

Over the past 25 years there have been a multitude of projects aimed at supporting farmers in northwest Vietnam to adopt sustainable farming practices. Since 2010 there have been at least 15 major projects working towards improving the economic and environmental sustainability of land management in northern Vietnam (Supplementary Table 1). Since 2000, 75 studies have been published (including 41 in peer—reviewed journals) on land management in northern Vietnam. These studies have focused on biophysical (36), social (8), economic (3) and combinations (28) of these aspects. Of the biophysical studies, 18 described the link between vegetation cover (e.g., corn) and soil health (e.g., erosion, fertility). Eleven studies described new approaches to land management, 44 described current conditions, and 20 studies looked at both new and current land management. These studies/projects have operated with a range of foci:

- Economic, environmental and social drivers of land use change;
- The relationship between farmers' livelihoods and the environment;
- Farmers' awareness of environmental degradation;
- Forest loss, reforestation and restoration;
- The environmental impact of corn cultivation;
    - The relationship between soil (i.e., fertility, erosion) and land management (e.g., intense mono-cropping of corn, soil conservation management [contouring, mulching, minimum tillage, hedgerows], perennial crops, agroforestry);
- Economic comparisons of agricultural crops, markets, value chains and market access;
    - Improving market access;
    - Economic impacts of corn cultivation;
- Farmers' response to climate, climate impacts (e.g., floods), impact of climate on farmer decisions;
- Reasons for farmers' adoption and non-adoption of sustainable land use methods, assessment of barriers to change;
- Government institutions that influence land management.

The conclusion that can be drawn from these studies is that in northern Vietnam intensive mono-cropping of corn is widespread and ongoing, and from the perspective of soil-erosion and loss of land production capacity, it is unsustainable, although unlikely to change soon.

Part 2: interviews with farmers: background information

The most common ethnic groups our study area were Thai and Muong, which together were the majority in four villages (Table 1). The other two villages in our study had majorities of Hmong and Dao people. According to the Vietnamese Government's poverty scale (Vietnam Government 2011, 2012, 2014), the villages ranged from being classed as having 'no difficulties' to being among the 'most difficult'. Pa Cop, the Hmong village, was categorised as 'most difficult', whereas the three villages with 'no difficulties' were one dominated by Dao, by Muong and by a combination of Muong and Thai. The mean number of adults per household was highest in Pa Cop. Sources of income, such as paddy rice and livestock, were not necessarily higher in the villages classified as 'no difficulties', compared to the 'difficult' and 'most difficult' villages. In terms of income sources other than corn, the Pang (Thai ethnic minority) villages had the highest numbers of cattle (4.9 ± 9.5) and buffalo (1.7 ± 1.7; Table 1), and had a moderate rating on the poverty scale. The other village with moderate poverty, Chieng Le (Muong-Thai), had the most paddy rice (2475 ± 2222 m^2; Table 1).

The majority of the farmers (75%), when asked about land tenure, stated that they had inherited the land from their parents. A small proportion of farmers (15%) had some land, usually the house land, for which they either had land-use rights, had bought, or been awarded ownership by the government. Twelve percent of the farmers said they had created upland cropping land by clearing forest. Respondents were vague about the total area of land which was available for them to cultivate corn, although most answers seemed to indicate around two hectares; it is because of this uncertainty that we do not present data on household dryland/upland cropping area. (Paddy rice area, in contrast, was known to the square metre.) It was typical for each household's dryland/upland cropping area to be in several plots, which may be several kilometres from the house. Corn production (per household) ranged from 2 to 42.5 tonnes, and there was a positive correlation between corn production and fertiliser application (slope = 0.01, $R^2 = 0.34$; Fig. 2).

Based on the farmer-stated costs of inputs and corn sale prices, average net family income from corn was estimated to be $1463 USD per year (based on the VND-USD exchange rate at May 2016), but individual household estimates ranged between $54 and $4246. All farmers except one sold corn to a middleman. Most farmers kept some corn for feeding animals (particularly pigs and chickens). Many farmers mentioned that inputs were purchased from middlemen 'on agreement' (i.e., that the corn crop would be sold to repay the loan/debt). No farmers inter-cropped corn with other crops.

Corn was typically grown for one season, after which the land left fallow for the remainder of the year. Approximately 1 week before planting the corn, the land was burnt to remove dry vegetation. Most farmers (78%) practised no/minimum tillage and all except three farmers burnt the sites in preparation for planting. These farmers did not burn their land because there was nothing left to burn after grazing by free-ranging animals. All farmers used herbicide. All except six farmers said they were aware of the potential for negative human health or environment outcomes from herbicide use, or more generally, of land degradation as a result of corn cultivation.

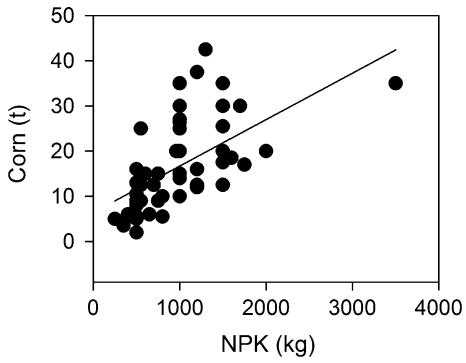

Fig. 2 Tonnes of corn produced per household in 2015 according to amount of NPK fertiliser. Results are reported in the units that are typically used by farmers (tonnes for corn, kilograms for fertiliser)

Part 2: interviews with farmers: farmers attitudes to growing corn and other species

The interviewers compared notes and classified farmers' responses around four main question topics:

(1) Why do you grow corn? What don't you like about growing corn? (Fig. 3)
(2) Which alternative crops have you tried to grow (current or past)? What alternative crops are you interested in growing in the future? (Fig. 4; Table 2)
(3) What are your main concerns about growing alternative crops? (Fig. 5)
(4) What are your main needs to help you change to growing alternative crops? (Fig. 6)

These responses are discussed in detail in the following paragraphs.

Most farmers said they grew corn because they "don't know any other species" (67%; Fig. 3a). The next most common responses concerned finances, "we do not have money for seedlings" (22% of farmers), and neighbours, "everyone was growing corn" and that they "don't want to be alone" in growing other species (17% of farmers). The next four most common responses (totaling 37%) were concerned with management issues, such as that corn is easy to manage and grow (12 and 7%, respectively), land is steep—with the implication that growing anything else would be difficult (10%), and animals, which would otherwise eat crops, were contained during the corn

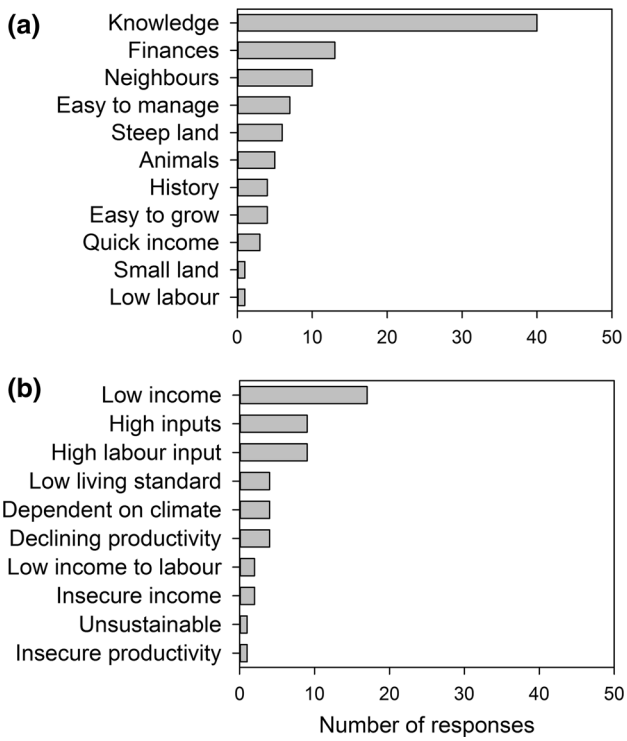

Fig. 3 **a** Why do you grow corn? **b** What don't you like about growing corn? Abbreviated answers shown in figure are described, in rank order, below. **a** (1) Knowledge, typical answer: "don't know any other species"; (2) Finances, typical answer: "don't have money for seedlings or inputs for other species"; (3) Neighbours, typical answer: "everyone is growing corn, we do not want to be alone"; (4) Easy to manage, because land is far from house and, or spread out; (5) Steep, typical answer: "land is steep", with the implication that growing anything other than corn would be difficult (similar to easy to grow and easy to manage); (6) Animals, livestock would eat the crops/animals are contained during the corn season; (7) History, typical answer: "we have been growing corn for a long time"; (4) Easy to grow; (9) Quick income; (10) Small land, typical answer: "we not have enough land, or money to rent land to grow other species"; (11) Labour, typical answer: "do not have labour to grow other species"; **b** (1) Low income; (2) High inputs, also high investment cost; (3) High labour input; (4) Low standard of living, typical answer: "growing corn does not increase standard of living", "income from corn not enough to live on"; (5) Dependent on favourable climate, or weather (production is); (6) Declining productivity; (7) Low income relative to labour; (8) Insecure income; (9) Unsustainable; (10) Insecure productivity

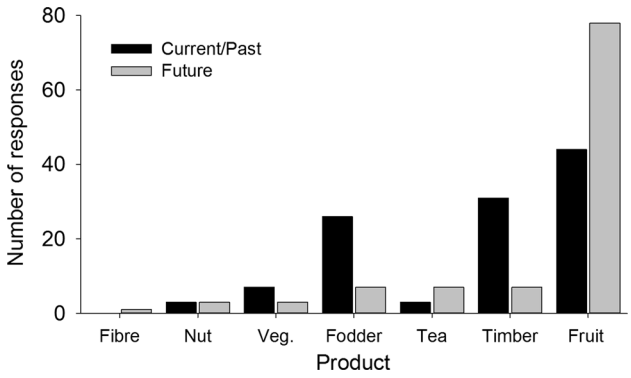

Fig. 4 Which alternative crops have you tried to grow (current or past)? What alternative crops are you interested in growing in the future?

growing season (8%). Only 5% of the farmers mentioned quick income as a reason for growing corn.

Many farmers did not directly answer the question "what don't you like about growing corn?" (Fig. 3b) possibly because it was an abstract question, and many people had already told us that they knew no alternative to growing corn. The most common problems with corn were around income (68%), specifically that income was low (28%), inputs were high (15%), labour investment was high (15%) or, that income from corn resulted in a low standard of living (7%) or income was low relative to labour (3%). Other dislikes, not explicitly mentioning income, were that growing corn was dependent on climate/weather, that productivity was declining or insecure, and that growing corn was unsustainable.

Farmers responded that they grew a range of crops other than corn (Fig. 4, Table 2), even though they had previously stated that they did not know any species other than corn. The most common crop was fodder grass (*Pennisetum purpureum*, 25%). The second and fourth most common species were native timber species: *Chukrasia tabularis* (23%) and *Melia azedarach* (13%). Five of the top ten tree species were fruit trees, these were longan (3rd), peach (5th), plum (6th), lychee (9th) and orange (10th).

When asked about alternative crops that they had not tried growing, but would like to grow, eight of the top ten species were fruit trees, and Shan tea and grass completed the top ten. Information on where people had learned about alternative crops was not answered by all interviewees, but tended to be personal observations (i.e., neighbours, nearby villages or television).

The most commonly cited barriers to growing alternative crops (Fig. 5), distinct from the reasons for growing corn, were not wanting to be the first to grow a new crop (38%), unreliable markets and income (23%) and uncertainty around suitability of climate/land for alternative crops (20%). The fourth most common concerns were: that alternative crops would take too long to produce income (13%) and the potential for damage from free ranging animals (13%).

What most farmers wanted the most to help them change to alternative crops was financial support (Fig. 6). The next most common needs were: seedlings, non-specific 'support', and then technical knowledge, specifically training to learn techniques to grow these alternative crops.

Discussion

Northern Vietnam has been host to a multitude of projects that have: documented the dual problems of severe erosion and declining soil fertility; attributed these problems to intense cultivation of steep slopes; and developed and promoted sustainable land management solutions. Our research focuses on a different (but related) problem: the limited uptake of sustainable land management practices. Our interviews revealed five key points: (1) farmers are dissatisfied with growing corn because of low income and high cost of inputs; (2) farmers think that they have no alternative to growing corn; (3) however, farmers are aware of alternative crops and are especially interested in growing grass and trees; (4) corn cultivation is considered to be normal, and associated with

Table 2 Alternative crops species names, category of use, and per cent of households that (1) would like to grow this species in the future (2) are growing/ have grown this species

Survey name	Scientific name	Category	% responses for future	% responses for current/past
Orange	*Citrus* × *sinensis*	Fruit	21	5
Longan	*Dimocarpus longan*	Fruit	13	9
Mango	*Mangifera* spp.	Fruit	10	2
Lychee	*Litchi chinesis*	Fruit	8	5
Shan Tea	*Camellia sinensis* var. *shan*	Tea	7	3
Mandarin	*Citrus reticulata*	Fruit	5	0
Fruit tree	Not specific	Fruit	4	1
Grass	*Pennisetum purpureum*	Fodder	4	13
Jackfruit	*Artocarpus heterophyllus*	Fruit	4	0
Melia	*Melia azedarach*	Timber; fodder	4	8
Lime	*Citrus aurantifolia*	Fruit	3	0
Peach	*Prunus persica*	Fruit; flowers	3	6
Canna	*Canna edulis*	Fodder; food	2	6
Grapefruit	*Citrus grandis*	Fruit	2	2
Peanut	*Arachis hypogaea*	Nut	2	2
Bamboo	*Dendrocalamus* spp., *Bambusa* spp., *Phyllostachys* spp.	Timber; vegetable	1	5
Bean	*Phaseolus* spp.	Vegetable	1	4
Cassava	*Manihot esculenta*	Fodder	1	4
Chayote	*Sechium edule*	Vegetable	1	0
Chukrasia	*Chukrasia tabularis*	Timber	1	12
Cotton	*Gossypium* spp.	Fibre	1	0
Dalbergia	*Dalbergia annamensis*	Timber	1	0
Macadamia	*Macadamia integrifolia*	Nut	1	1
Plum	*Prunus salicina*	Fruit	1	6
Pumpkin	*Cucurbita* spp.	Vegetable	1	1
Water melon	*Citrullus lanatus*	Fruit	1	0
Avocado	*Persea* spp.	Fruit	0	1
Banana	*Musa* spp.	Fruit	0	2
Pine	*Pinus* spp.	Timber	0	1
Potato	*Solanum tuberosum*	Vegetable	0	1
Taro	*Colocasia esculenta*	Vegetable	0	1
Teak	*Tectona grandis*	Timber	0	1

reliability of income; (5) income is a key constraint on farmers' ability to change land management. Farmers' concerns about the reliability of markets and income, alongside their familiarity with alternative crops, suggests that the key barrier to adoption of sustainable land management in Van Ho is the perceived unreliability of income for crops other than corn.

Farmers' focus on income was not unexpected. The farmers had a low economic status, which is typical for upland farmers in northwest Vietnam. Establishment

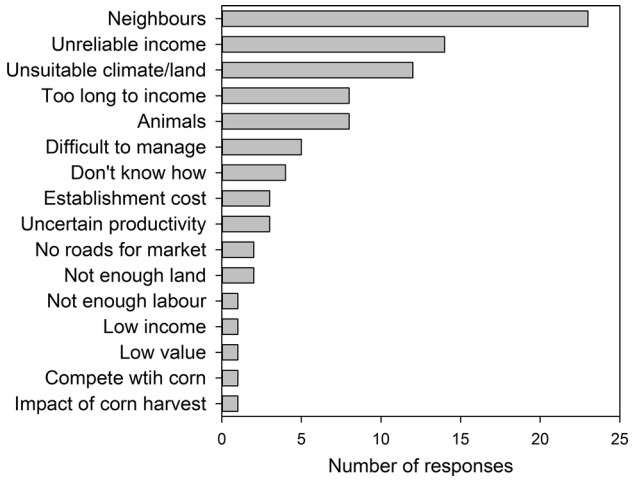

Fig. 5 What are your main concerns about growing alternative crops? Abbreviated answers shown in figure are described, in rank order, below. (1) Neighbours, includes answers such as "don't want to do it alone", "don't want to be the first"; (2) Unreliable income, including unstable and unreliable markets; (3) Unsuitable climate or land, indicates land or climate is thought to be unsuitable for growing alternative crops; (4) Too long to income; (5) Animals, livestock would eat the crops of alternative species/livestock are contained during the corn season; (6) Difficult to manage, especially when lands are far from home; (7) Do not know how; (8) Establishment costs are limiting; (9) Uncertain productivity; (10) No roads for market, roads are limiting; (11) Not enough land; (12) Not enough labour to grow alternative crops/alternative crops take too much labour; (13) Low income; (14) Low value; (15) Compete with corn, will compete with corn if intercropped; (16) Impact of corn harvest, plants may be damaged during corn field preparation, planting and harvest

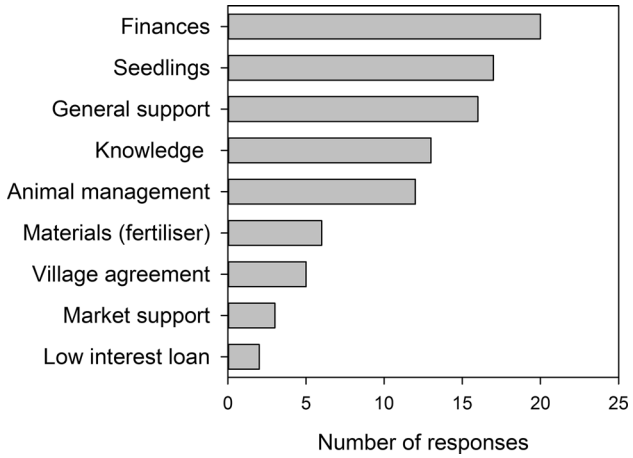

Fig. 6 What do you need most to help you change to an alternative crop? Abbreviated answers shown in figure are described, in rank order, below. (1) Finances, typical answers included: "budget", "money"; (2) Seedlings; (3) General support, typical answers were non-specific statement about needing support, may refer to finances; (4) Knowledge, typical answers included: "training" "support to learn techniques"; (5) Animals, typical answers "need animal management to stop damage to crops", especially free ranging animals in the outside corn-growing season; (6) Materials, typical answers included "fertiliser"; (7) Village agreement, a formal agreement or simple support from others in the village, including more people growing the alternative crop; (8) Market, typical answers indicated want for support to develop a market; (9) Low interest loan

costs, in addition to the wait for alternative crops become productive, can be an insurmountable barrier to their adoption (Hoang et al. 2013; Nguyen et al. 2013a). In many cases the problem appeared to be circular: corn produces little income, but money is required to change to alternative crops.

Most farmers sold their corn crop to a middleman. The purchasing of corn by local middlemen helps to provide income security. Middlemen play an important role in arranging for transport of corn from remote farms, often paying cash on product collection, and in managing corn supply and demand (CGIAR 2014). Perception, and data (Fig. 2) indicate a strong correlation between production and fertiliser addition, encouraging increasing investment in inputs (commonly supplied by middlemen), potentially resulting in a debt trap, if production is lower than expected. The income from corn was low (1700–2800 VND or 0.08–0.13 USD per kg), but corn was nevertheless highly valued as a reliable source of income—this reliability is facilitated by a clear production-to-commercialisation chain in which middle men are an essential link.

Many farmers in Van Ho are already growing grass and trees on small areas of land—and this is complementary to the wide range of species which farmers indicated that they would like to grow. Almost all the farmers had tried to grow alternative crops, and most farmers expressed clear preferences for timber and fruit tree species they would like to grow, with variation in species likely a function of personal preference and local environmental conditions.

Farmers' almost universal acknowledgement of the value of grass was not surprising, if simply because most farmers also owned small numbers of cattle or buffalo. Grass grown in these systems is commonly used for livestock feed, either as a 'cut and carry' product or supervised grazing (e.g., Nguyen et al. 2013b). Livestock raising is considered to be a high-value industry, with potential to reduce poverty rates in smallholder upland farmers in Vietnam (given a supportive policy environment; Le et al. 2013; Millar and Photakun 2008). Growing grass on steep slopes also improves soil retention and fertility as it breaks and filters runoff (e.g., Xu et al. 2012, China; Thapa et al. 1999, Philippines; reviews in Craswell et al. 1998 and Valentin et al. 2008). Our results suggest that the main barriers to expanding grass crops in Van Ho appear to be management challenges, such as the risk of damage from neighbours' livestock, disruption of corn harvest, and the perception that grass will compete with corn.

Fruit and timber trees were also popular alternative crops. Growing trees on steep slopes reduces erosion and improves soil fertility (compared to monoculture annual crops, Islam and Weil 2000). Working in the Philippines, Bertomeu (2012) concluded that combining tree species *Eucalyptus deglupta* and *Gmelina arborea* with corn was more profitable than either pure corn cropping or growing woodlots. In a similar manner to livestock raising, fruit growing is considered a high value industry with the potential to improve livelihoods (Weinberger and Lumpkin 2007), and indeed can increase farmers' income resilience to extreme weather events (compared to annual crops, Simelton et al. 2015). Fruit growing is a major target for agricultural development in Vietnam (decision 899/QD TTg; Nguyen 2015). Hence, one of the reasons for high awareness of fruit growing in Van Ho could be because Hoa Binh is a province which straddles the route from Van Ho to Hanoi and has been the focus of government initiatives which promote fruit growing (Rake et al. 1993). The proximity of Van Ho to Hoa Binh is also important from the perspective of access to markets and processing facilities. In terms of growing trees for timber, *Acacia* production for wood chips, which has very been successful in other parts of Vietnam, is thought to be less viable in northwest Vietnam due to slower growth rates and higher costs associated with transport (Kien and Harwood 2016). Alternately, markets may be emerging for local sawn timber, as timber from natural forest becomes impossible to source (Kien and Harwood 2016). We found many farmers were growing small numbers of trees for timber (mainly *Melia* and *Chukrasia*) although they were unhappy about the long time between planting and production/income. The reason why tree growing is not more widespread is low short-term profitability—a particular problem for the poor (Sunderlin et al. 2005). We suggest that if a regular income, equivalent to that from corn, could be guaranteed, farmers may adopt alternative crops, such as grass, fruit trees and timber trees, at a larger scale.

Land tenure is widely accepted as being fundamental to farmers' decisions, especially whether to invest in soil conservation (Shivley 1996) and tree crops (Mercer 2004). Farmers interviewed for this study did *not* focus on land tenure as a reason for land management decisions. In Vietnam, the certificate of land use rights is known as 'Red Book', and is granted for periods of up to 50 years. Red Book certification is among the most important legislative factors in determining land use (Tran Lam Dong, Vietnamese

Academy of Forest Science, pers comm.). If a farmer has Red Book, benefits include compensation if the land is compulsorily acquired, and the ability to use the Red Book as collateral when applying for loans. The reasons for the lack of discussion on the influence of Red Book in our interviews remain unclear, although one explanation may be that farmers' understanding of their land rights is poor, as in Central Vietnam (see Knudsen and Mertz 2015).

Accessibility (i.e., location with respect to major roads and markets) is another well-known determinant of land use and agricultural product value (Cevero 1990; Castella et al. 2005; Chi et al. 2013). Farmers in Van Ho mentioned several projects that had successfully introduced new species, only to have these plantings destroyed when there was no market for the produce. Van Ho has seven processing facilities for tea, one for bamboo and one for oranges; other products must be transported outside the province for processing. The increasing popularity of Shan tea may also be partly attributable to these processing facilities, as well as ease of transport and storage, relative to fruit.

The influence of the local community on land use decisions is clear: in general, farmers prefer to grow the same crops as their neighbours. This is likely a result of the need to manage individual financial risk (by choosing crops for which there is an established production-to-commercialisation chain) and to follow community norms. A study of a community in Hoa Binh, northern Vietnam (Clement and Amezaga 2008) provides an illustration of the influence of community on individual farmer crop choices. This community stopped growing corn and started growing trees. This change was driven by damage to corn crops by cows and buffaloes, and soil paucity, which ostensibly led to low productivity. These factors led to a positive feedback cycle in which fewer people grew corn, there was consequently less community care in controlling free-ranging animals, which led to more damage to crops, and fewer people growing corn (Clement and Amezaga 2008). In Van Ho, however, animal grazing provides the opposite motivation. The farmers who we interviewed cited agreements to contain grazing animals during the corn-growing season from May to October, while allowing free grazing for the rest of the year. This puts perennial seedlings, which grow outside this period, at significant risk. Several farmers suggested this risk could be easily addressed by creating new containment rules, or fining the owners of animals that damage crops.

There is no one single reason why the many projects on improving sustainability of farming in northern Vietnam have not deterred the farmers of Van Ho from intensively growing corn. One reason might simply be information dissemination—that projects were not active in Van Ho, or in the villages we visited. Another reason might be the lack of national- and provincial-level policy support of agroforestry in Vietnam (Simelton et al. 2017). Nevertheless, our interviews yielded recommendations for future projects. Having a sound production-to-commercialisation chain is likely address many of the potential issues around income security when moving to alternative crops. Projects which provide seedlings and training, but no commercialisation support, are unlikely to have a long-term impact. Another consideration for future projects is maintenance of both short-term and long-term income—this is especially the case for projects promoting tree growing. In addition, rather than trialing new alternative crop species, future projects might consider leveraging farmers' knowledge of (and interest in) biophysically suitable alternative crop species—investing in trials which test productivity on challenging/low quality sites (e.g., those which have historically reserved for corn). Finally, while the benefits of agricultural diversification are well known (e.g., resilience to changing environmental conditions, Lin 2011; food security, health and increased income, Kahane et al. 2013), diversification success is reliant on market demand and accessibility (Barghouti et al. 2004; Kahane et al. 2013). The results from our study may indicate that diversification should be limited on these smallholder farms—so that efforts on development of production-to-commercialization chains can be focused.

Future projects to improve the sustainability of steep slope management in Vietnam may consider agroforestry systems using a combination of fruit trees (orange, longan and mango), timber trees (*Melia* and *Chukrasia*), tea hedges (*Camellia sinensis* var. *shan*) and other species of interest identified by farmers, with grass planted in contour strips (following the principles of SALT; described Tacio 1993). Corn crops may be maintained for several years before competition (e.g., shading from trees) decreases production. Such systems would have the potential to reduce erosion, provide short-term income (from corn, grass and then

fruit) and long-term income (from timber). A number of other promising agroforestry systems are described by Simelton et al. (2017). Any future agroforestry projects must take a community-level and collaborative approach (i.e., including the development of regulations to prevent free-range grazing), have a clear plan for farmers' income in the years before production, provide product commercialization support, as well as providing seedlings, fertilizer and technical advice.

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