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Tree-cover transition in Northern Vietnam from a gender-specific land-use preferences perspective

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ABSTRACT

Vietnam is one of the countries where a shift from net deforestation to net reforestation is taking place. This study examines the pattern of tree-cover transition and gender-specific land-use preferences and decisions in northern Vietnam. We employed a mixed-method approach that combined a land-use transition analysis, gender-disaggregated survey and role-playing games (RPG) to assess the relationship between tree-cover transition and gender. The first two methods revealed continuous conversion of protection forest to tree plantations and upland crops (dominated by swidden rice). Factors affecting conversion identified through regression analysis were elevation and labor availability. The land-use RPG revealed gender-specific preferences for annual crops and tree-based agroforestry systems, and the underlying motivation of those preferences. The overall pattern of tree-cover transition in northern Vietnam falls under the smallholder agricultural intensification path. Agroforestry potentially balances the specific land-use preferences of men and women, and helps to achieve their specific land use related livelihood objectives.

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1. Introduction

Forest- or tree-cover transition from net reduction to net expansion has been recently observed in many tropical countries (Meyfroidt and Lambin, 2011). The forest transition theory, which was primarily developed in the context of forest recovery in (industrial) temperate regions as a consequence of economic changes (Mather and Needle, 1998), has been widely explored in the tropics to better understand patterns of forest-cover transition (Mather, 2007; Meyfroidt and Lambin, 2008a, 2008b; Rudel et al., 2005). Vietnam is one of few countries where forest transition is taking place; a net increase in forest cover between 1993 and 2005 using the 2006 FAO data was observed due to increased in forest plantations, but does not say anything about the quality of the forest (cover) (Meyfroidt and Lambin, 2010).

Understanding tree-cover transition in the tropics depends on various factors and produced mixed results (i.e., different from the ones observed in industrial countries) (Lambin and Meyfroidt, 2011; Perz, 2007). Because claims regarding forest-cover transition are often based on official forest-cover estimates, forest dynamics and geographical contexts that underpin transition processes are important considerations (Perz, 2007). One novel aspect of this study relative to other forest-cover transition studies is the explicit treatment of gender-specific aspects that may affect forest- or tree-cover transition. Men and women within households often have gender-specific roles, land-use preferences and perspectives that may influence land-use transition processes (van Noordwijk and Villamor, 2014; Villamor et al., 2015). Taking into account gender-specific land-use decision making may provide important insight for future forest and agricultural initiatives in the tropics.

Vietnam underwent a socio-political process that led to more equitable allocation of land-use rights and contributed to widespread poverty reduction (Phong and Glewwe, 2002 Ravallion and Van de Walle, 2003). Kozel (2014) reported that poverty headcount fell remarkably to 14.5% in 2008 to below 10% in 2010. In spite of the positive impacts of this land-use rights allocation process on agricultural and rural development, forest fragmentation became an issue due to the emphasis on equitable land allocation. The World Bank (2003) estimated that there were about 75 to 100 million land parcels throughout the country in 2002. Consequently, between 1990 and 2005, agricultural intensification by smallholder farmers was widespread, particularly in marginal agricultural areas (Gordon MacAulay et al., 2006; Meyfroidt and Lambin, 2008b). Accordingly, this forest transition pathway is characterized by well-

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defined land tenure rights and without declines in agricultural land uses or local populations. Instead, population growth drives local agricultural intensification and diversification by increasing labor input in suitable areas, and occurs predominantly in agriculturally marginal areas (Meyfroidt and Lambin, 2008a). Linking this type of land-cover transition with gender-specific decision making and preferences is innovative and may provide insight into the socio-ecological resilience, functionality and sustainability of a landscape (Cumming et al., 2006; Meinzen-Dick et al., 2014). Thus, in this study we explored the relationship between gender-specific land-use preferences and decisions and the agricultural intensification process occurring in an agriculturally marginal forested region of northern Vietnam. The objectives of the study were to: (1) assess tree-cover transition in northern Vietnam by determining the land-use categories that were *targeted* or *avoided* between 2000 and 2010; (2) determine the factors associated with gender and related decisions that affect tree-cover area; and (3) predict the likely transition pathway for the study area under a scenario of competing options based on gender-specific preferences and decisions.

1.1. Gender and tree-cover transition

Social and ecological systems can interact in many ways and often create dynamic feedback loops through which humans both influence and are influenced by ecosystem processes (Levin, 1999). The complexity of land uses at the landscape level often results from local interactions among individuals. Such individuals may have gender-specific perceptions that affect their land-use preferences and decisions that in turn may influence tree-cover transition and landscape multi-functionality (Villamor et al., 2014b). Hence, tree-cover transition is linked to overall land-use change (Barbier et al., 2010), associated socio-ecological changes and feedback (Lambin and Meyfroidt, 2010), and by contextual factors (Perz, 2007). However, few studies have investigated gender-specific decisions, behaviors and preferences at the landscape level (Villamor et al., 2015). The main purpose of this study was therefore, to understand gender-specific land-use preferences, decisions and actual practices, and how will these influence future land-use change.

In this study, we adapted the concept of emergence by exploring gender-specific interactions that result in tree-cover patterns or trends (Holland, 1992; Holling, 1978), and explored the hypothesis posed by van Noordwijk and Villamor (2014) that appreciation of tree-cover and its associated ecosystem services varies according to gender and ecological knowledge.

2. Materials and methods

2.1. Study area

The study was conducted within the communes of Muong Do, Tuong Tien and Tuong Phong in the Phu Yen district of Son La province in northwest Vietnam. The three communes have a total combined land area of 17,523 ha (Fig. 1). The study area is located in one of the poorest regions of the country (Minot, 2006). These communes were selected because they are representative of the elevation gradient in the watershed (lowland and mid-elevation sites). Elevation criteria were an important consideration for the selection of study sites because of associated changes in tree cover. The study area is located within a watershed that is undergoing rapid tree-cover transition and the drivers of land-use change (i.e., population growth and market forces) are evident (Meyfroidt and Lambin, 2008a). We focused on lowland and mid-elevation areas because the upland areas of the landscape are completely forested and protected by law for conservation purposes due to high level of endemism of flora and fauna.

In 2013, the population in the Phu Yen district was approximately 1.2 million, a 7.8% increase from 2000, of which 86% reside in rural and mountainous areas (Son La Statistical Book, 2014). Forty percent of households were reportedly below the poverty line (Nguyen and Lund, 2012). The Moung Do commune is part of the national government's 2009–2020 Development Plan in which, lands are allocated for agro-industrial production, whereas some areas in the district are allocated for perennial fruit tree production such as tea, mango, longan and litchi.

2.2. Data collection

The study applied a mix-method approach, which combined sex-disaggregated surveys, land-use intensity analysis and role-playing games (RPG) to account the scale aspect of decision making (e.g., individual vs. group decisions). A total of 302 respondents (of which 152 were females and 150 were males) were interviewed using a survey questionnaire. The respondents were selected through random stratification (i.e., elevation and gender). The survey questionnaire explored the households' socio-economic and farm characteristics, current land-use practices and land-use preferences. Thirteen percent of the female respondents and 96% of males were household heads. It is natural to find few female household heads in the study area, so rather than headship and intra-household power relations, our study focused on understanding segregated and mixed gender land-use preferences and decisions, which could impact future land-use patterns. The survey was conducted between May and June 2013.

A land-use intensity analysis based on a simple mathematical approach developed by Aldwaik and Pontius (2012) was used to assess land-use change dynamics. We used two land-use maps of the Son la province from the General Department of Land Administration (GDLA) within the Ministry of Natural Resources and the Environment (MONRE) covering the periods, 2000–2005 and 2005–2010. These maps were based on land-use inventories conducted every five years, site visits, and annual statistical information as opposed to remote sensing information. The land use descriptions are shown in Table 1.

We employed a modified version of the land-use RPG described in Villamor and van Noordwijk (2011) and Villamor (2014). The game was designed to capture gender-specific preferences that could affect land-use patterns at the landscape level. Without ruling out the influence of power relations between men and women in land-use decision making, the objective of the game was to observe how men and women may differ in their response to land-use options and how these responses contribute to either the conservation or conversion of existing land uses. It is assumed that individual farmers consult with one another and external actors about land-use practices, or are otherwise, influenced by local land-use changes. The RPG includes a board consisting of a 5×5 grid representing a village and its surroundings with key land-uses. Male and female participants in RPG were assigned to specific roles to portray in the game, such as farmers, government officials, logging and agro-industrial companies, and conservation agencies. Each game entails five "rounds," each of which represents an annual cycle that in this case, reflected the 2005–2010 period. The detailed mechanics of the RPG are described in Villamor (2014) and Villamor and van Noordwijk (2011).

A total of 18 RPG groups were conducted with the survey respondents who were grouped into three categories: (1) three men-only and three women-only groups from the lowlands that are dominated by the Phong ethnic minority (6 groups in total); (2) three men-only and three women-only groups from the mid-elevation areas dominated by the Tien ethnic minority (6 groups in total); and (3) six mixed-gender groups from lowland and mid-elevation areas. The grouping design was intended to elucidate the effects

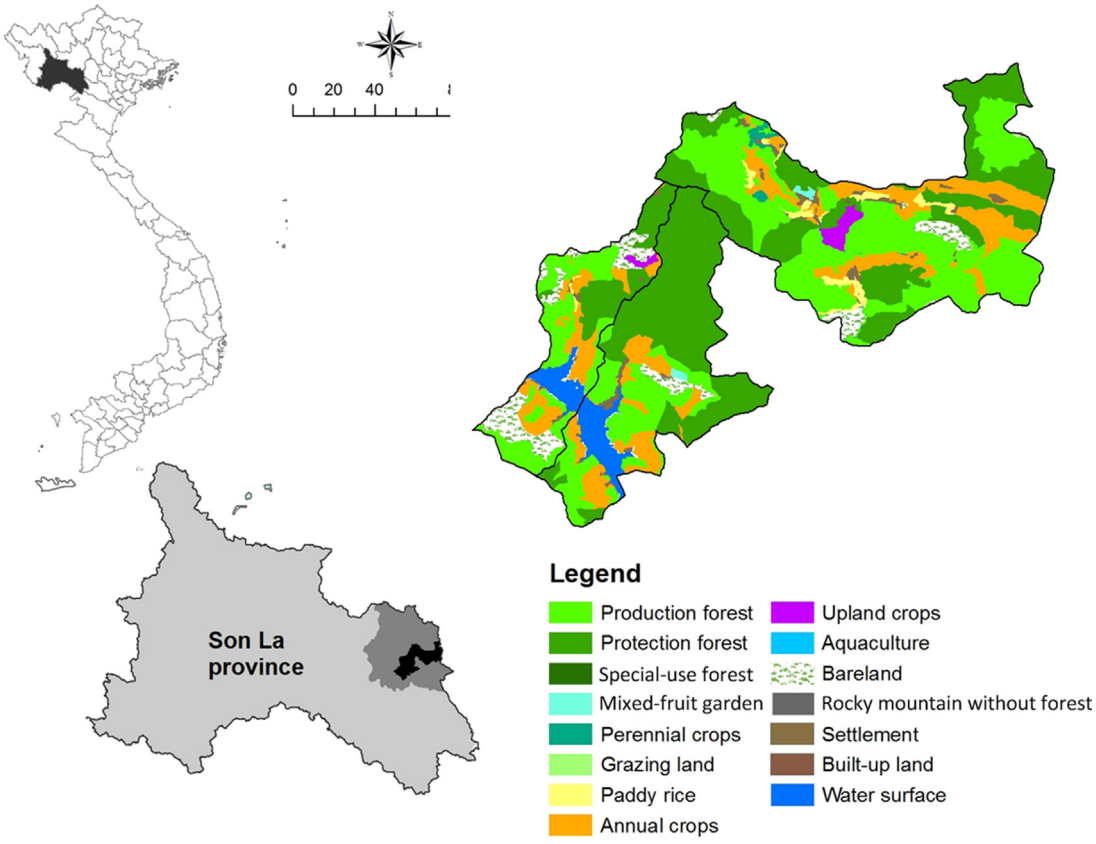

Fig. 1. The study area.

Table 1
Land uses in the study area.

No	Land-use type	Definition/description
1	Special use forest	Primarily for preserving natural forest resources and related flora and fauna, as well as for protecting historical sites and aesthetic quality for a combination of tourism and environmental protection purposes (scientific research is allowed in these areas)
2	Protection forest	Primarily for protecting and enhancing ecosystem services such as hydrological regulation, soil conservation, erosion control and desertification prevention, mitigating the effects of natural disasters and climate change
3	Production forest	Primarily for the production of timber and non-timber forest products with some protection and conservation functions: includes forests for natural regeneration and plantations that consist of tree species such as *Pinus* sp., eucalyptus, neem and teak
4	Bareland	Primarily grass and shrub cover with scattered trees
5	Perennial crops	Long term industrial crops such as sugar cane, coffee, rubber and tea: in the Phu Yen district tea is the main industrial crop
6	Mixed fruit plantations	Primarily mixed fruit tree systems with species such as plump, apricot, longan, *Diospyros kaki*, banana, mango, and litchi
7	Annual crops	Primarily maize, potatoes and cassava
8	Rice paddy	Primarily seasonal rice production
9	Upland crops	Swidden cultivation of rice or cassava
10	Settlement	Includes roads, military facilities, developed, and residential areas
11	Water bodies	Rivers, streams, etc.,

of gender-specific land-use decisions; however, it was not possible to control for ethnic-based differences in land-use preferences due to the spatial, elevational, and ethnic segregation of settlements in the study area. After each game, a reflection exercise was conducted to validate some results of the game and facilitate group discussion regarding the overall game experience. The reflection exercises were documented by the game facilitators. The RPGs were conducted immediately after the household survey. Unfortunately, the local government did not allow the RPG in Moung Do commune due to on-going government activities in the area. Consequently, our comparative analysis was limited to the low and mid-land elevations and the dominant ethnic minority groups in those areas.

2.3. Data analysis

The survey data were analyzed using logistic regression to determine the factors associated with land-use change (including tree-cover). Descriptive statistics generated using STATA 12 software were used to identify gender-specific land-use preferences. We employed a land-use intensity assessment program available from Google (at https://sites.google.com/site/intensityanalysis). The analysis focused on the land-use categories relevant to the landscape level transition trends and systematically targeted or avoided these categories during the two time intervals using the following formulas (Aldwaik and Pontius, 2012):

$$W_{tn} = \frac{(\text{area of gain to } n \text{ during } [Y_t, Y_{t+1}])\,100\%}{(\text{duration of } [Y_t, Y_{t+1}])\,\text{area of non} - n\text{at } Y_t}$$

$$= \frac{\left[\left(\sum_{i=1}^{J} C_{tin}\right) - C_{tnn}\right] 100\%}{(Y_{t+1} - Y_t)\sum_{j=1}^{J}\left[\left(\sum_{i=1}^{J} C_{tij}\right) - C_{tnj}\right]}$$

$$R_{tin} = \frac{(\text{area of transition from } i \text{ to } n \text{ during } [Y_t, Y_{t+1}]\ 100\%)}{(\text{duration of } [Y_t, Y_{t+1}] \text{ area of } i \text{ at } Y_t)}$$

$$= \frac{C_{tin}100\%}{(Y_{t+1} - Y_t)\sum_{j=1}^{J} C_{tij}}$$

where, Y_t is the year at point t; t is the index value for the initial point of time in interval $[Y_t, Y_{t+1}]$ where t ranges from 1 to $T-1$; J is the number of categories; j is the index value for a category at an interval's final time point; m is the index value for the losing category for the selected transition; n is the index value for the gaining category for the selected transition; C_{tij} is the number of pixels that transition from category i to category j during interval $[Y_t, Y_{t+1}]$; and R_{tin} is the intensity of annual transition from category i to category n during interval $[Y_t, Y_{t+1}]$ relative to the size of category i at time t, where $i \neq n$ and W_{tn} is the uniform intensity of annual transition from all non-n categories to category n during interval $[Y_t, Y_{t+1}]$ relative to the size of all non-n categories at time t. For the RPGs we followed a similar calculation based on the equations above by recording the number of land categories in transition per round using the score sheet (Villamor and van Noordwijk, 2011) and analyzed the results using a Microsoft Excel spreadsheet.

3. Results

3.1. Land-use transition intensity

The overall land-use changes between 2000 and 2010 are presented in Table 2. The overall land-use transition for the period is depicted in Fig. 3. In the recent time interval (2005–2010), the two apparent land-use trends are: (1) a decrease in the area of protection forest (9%), bareland (24%), and upland crops (11%); and (2) an increase in the area of production forest (27%) and annual crops (15%). During this time interval, the greatest change was in the transition of protection forest (red box in Fig. 2). Areas of protection forest have been converted to production forest at an annual rate of 10%. Upland crops were converted at an annual rate of 15%. Built-up areas were converted at an annual rate of 20%, which include areas for roads and bridges and other infrastructure. Areas of upland crops (i.e., swidden rice production) were converted to rice paddy and annual crop production at annual rates of 13% and 11%, respectively. Although, some production forests were reverted to protection forest, the rate of change from protection to production forest was almost three times higher than from production to protection forest. Meanwhile, the barelands were converted to production forest and perennial or annual crops.

Fig. 3 summarizes the key land uses that are being targeted and avoided. Annual crop gains *targeted* the loss of rice paddy and perennial or upland crops, and *avoided* protection and production forests (Fig. 3a). Bareland (or logged forests) gains *targeted* the loss of upland crops, whereas losses *targeted* gains in the area of annual or perennial crops and protection forest (Fig. 3b). Protection forest gains *targeted* the loss of production forests and *avoided* bareland and upland crops, while protection forest losses *targeted* gains in the area of production forests and upland crops (Fig. 3c).

3.2. Individual characteristics and determinants of land-use transition

The respondents' characteristics are summarized in Table 3. The average household landholding was 3 ha. Farmlands are typically highly diverse, with rice paddies, annual crops, agroforestry, mixed crops, fallow areas, and forest plots. The main sources of household income are annual crops (cassava, maize) followed by rice and perennial crops. The men reported slightly larger plot sizes, more farm plots, and greater labor availability than women. However, although men typically have greater total annual income, the maximum gross income was higher for women than men.

On average, 42% of the respondents' farms are currently under perennial or tree-based production, while the remaining areas are a combination of other land uses. About 50% of the respondents (of which 46% were women and 55% were men) reported changes in their current land uses. Due to land use profitability, almost 90% of the respondents preferred to convert current land uses to annual crop production. About 88% (N = 133) of women and 89% (N = 134) of men preferred annual crops, suggesting that there is no gender difference in terms of land-use choice. This preference for annual crops is consistent with the results of the land-use intensity analysis, suggesting that other land-uses types (i.e., upland crops, perennial crops, and rice paddies) will continue to be converted to annual crops (Fig. 3).

Seven variables were significantly associated with respondents' decisions to change land uses (Fig. 5), which are number of mobile phones or communication ($p < 0.05$), number of years of education ($p < 0.05$), number of group membership ($p < 0.05$), total agroforestry system area ($p < 0.05$), labor availability ($p < 0.05$), Moung Do ethnicity ($p < 0.01$) and Phong ethnicity ($p < 0.05$) (Fig. 5). Among these seven variables, labor availability had the greatest influence on the decision to change current land uses (65% probability), followed by household size (63% probability), and dependency ratio (34% probability; but not significant). This suggests that labor, which mainly comes from the family, is an important determinant of prevailing land uses in the study area. Using predicted margins, the probability that a male would choose to change their current land use is slightly higher (53%) than for a female (50%). In terms of ethnic group or communes, the Tien ethnic group had the highest probability of changing land use (62%), followed by the Moung Do commune (48%), and the Phong ethnic group (42%). Annual crops are highly preferred by all dominant ethnic groups or commune members.

3.3. Gender-specific land-use change: role-playing game

The overall hypothetical land-use changes based on the results of the RPGs are summarized in Fig. 5. On average, both female-only groups from the two communes had the highest number of land-use changes, whereas the male-only groups had the least land-use change. Further, the Phong ethnic group exhibited the highest number of land changes. The RPG results are described below according to specific land-use categories.

3.3.1. Lowland site (Phong ethnic group/commune)

Of the total area selected for land-use change (68% of all plots) by the female-only groups in the lowland site, 33% was allocated to sugar cane, 20% to agroforestry and 15% to protection forest. Sugar cane is a highly preferred perennial crop among women due to the high financial returns (Fig. 5a). Agroforestry is also a preferred land use among women because it is an important source of food for household consumption (most agroforestry systems are located near the houses). The women expressed a negative view of production forest because they were unfamiliar with the practices entailed in the management of these areas and timber has longer-term cycle. However, they expressed awareness of the forest protection law in the area.

In contrast, the men-only groups from this site chose to maintain production forests (Fig. 5a), and expressed a desire to convert protection forest to production forest. For men, production forests yield higher income over the long term (i.e., over six years) and serve as a source of timber for house construction and maintenance. Furthermore, the men reported that the soil condition in their area is unfavorable for sugarcane production, which was not mentioned

Table 2
Land-use change during the periods, 2000–2005 and 2005–2010.

Category	2000	%	2005	%	2010	%	Land change (%) 2000–2005	2005–2010
Protection forest (Prot'n)	4121	23.5	7837	44.7	6189	35.32	21.2	−9.41
Production forest (Prod'n)	4417	25.2	1427	8.1	6231	35.56	−17.1	27.42
Bareland	6239	35.6	5276	30.1	1014	5.79	−5.5	−24.32
Upland crops	1778	10.1	2114	12.1	175	1.00	1.9	−11.07
Rice paddy	62	0.4	72	0.4	274	1.56	0.1	1.15
Settlement	243	1.4	91	0.5	263	1.50	−0.9	0.98
Perennial crops	0	0.0	79	0.4	80	0.46	0.4	0.01
Annual crops	0	0.0	0	0.0	2618	14.94	0.0	14.94
Other (Built-up, mixed-fruit, water bodies, etc.,)	662	3.8	627	3.6	679	3.87	−0.2	0.30
Total (ha)	17,523		17,523		17,523			

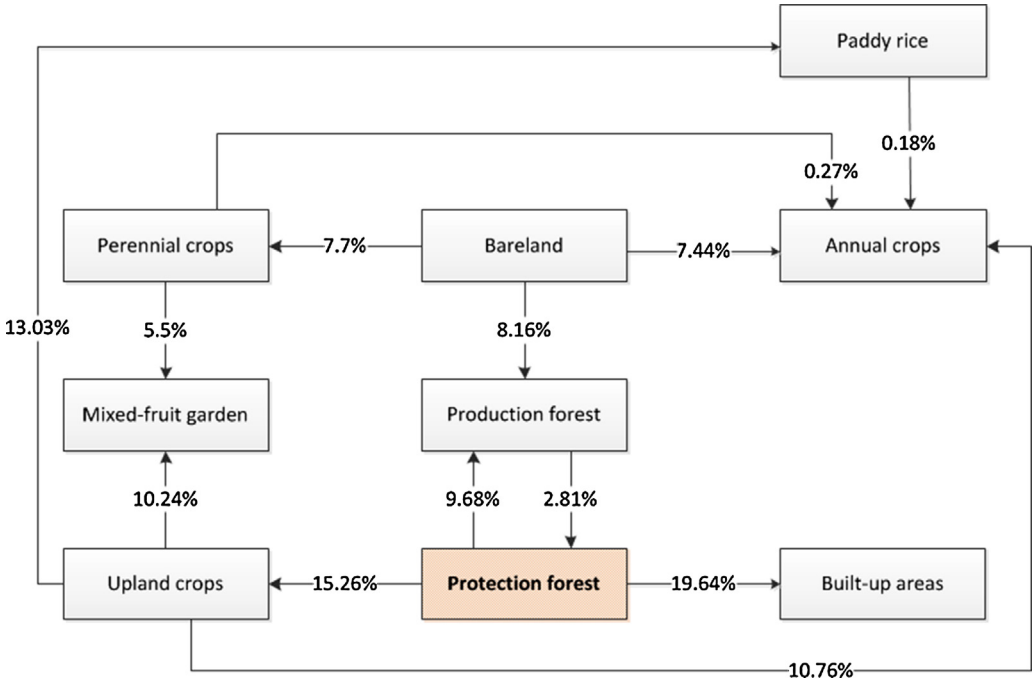

Fig. 2. Land-use changes (percentages) between 2005 and 2010 (Aldwaik and Pontius, 2012; Villamor et al., 2013).

in the women-only groups. Of the total area selected for land-use change (45% of all plots) by the men-only groups, 19% was allocated to sugarcane, 13% to protection forest, 10% to agroforestry, and 3% to production forests.

The land-use preferences of the mixed-gender groups from this site were quite similar to that of the female-only groups. The targeted area for change was 70% of the total land area, and was allocated to the following: 30% to sugarcane, 28% to agroforestry, and 12% to protection forest. Although overall, sugarcane is slightly more preferred than agroforestry, both men and women agreed that agroforestry areas should be expanded due to the diversity of vegetables, fruits, and timber that households can benefit from.

3.3.2. *Mid-elevation site (Tien ethnicity/commune)*

Of the total area selected for land-use change (53% of all plots) by female-only groups in the mid-elevation site, 23% was allocated to annual crops, 16% to agroforestry, and 7% each to protection and production forests (Fig. 5b). Women from this commune were more expressive about their choices compared to men. Women participants reported preferences for both annual crops (e.g., maize, cassava and vegetables) and agroforestry because these land uses are primary household food sources. They expressed confidence on their preferences, since they already have a long experience with these land uses.

Of the total area selected for land-use change (36% of all plots) by the male-only groups in this site, 16% was allocated to production forest, 13% to annual crops, and 7% to agroforestry. Clearly, the men in this site were more conservative or careful in opting for land-use changes. They kept some fallow plots throughout the RPG, and tend to favour tree-base systems for soil and water conservation, and longer-tem income security.

The areas of land persistence and annual crops were quite similar between mixed gender and male-only groups (with no areas for protection forests allotted). Of the total area suggested for land-use change (41% of all plots) by the mixed gender group in this site, 23% was allocated to agroforestry, 15% to annual crops and 3% to production forest. In the mixed groups, both men and women agreed that agroforestry provide greater benefits than annual crops due to their contribution to soil fertility, as well as timber production over the long term. Production forest was less preferred in this site due to the perceived threat of forest fire associated with this land use.

4. Discussion

4.1. *Tree-cover transition and gender specific land-use preferences*

Results from the transition intensity analysis indicate that protection forest areas continue to be converted to other land uses,

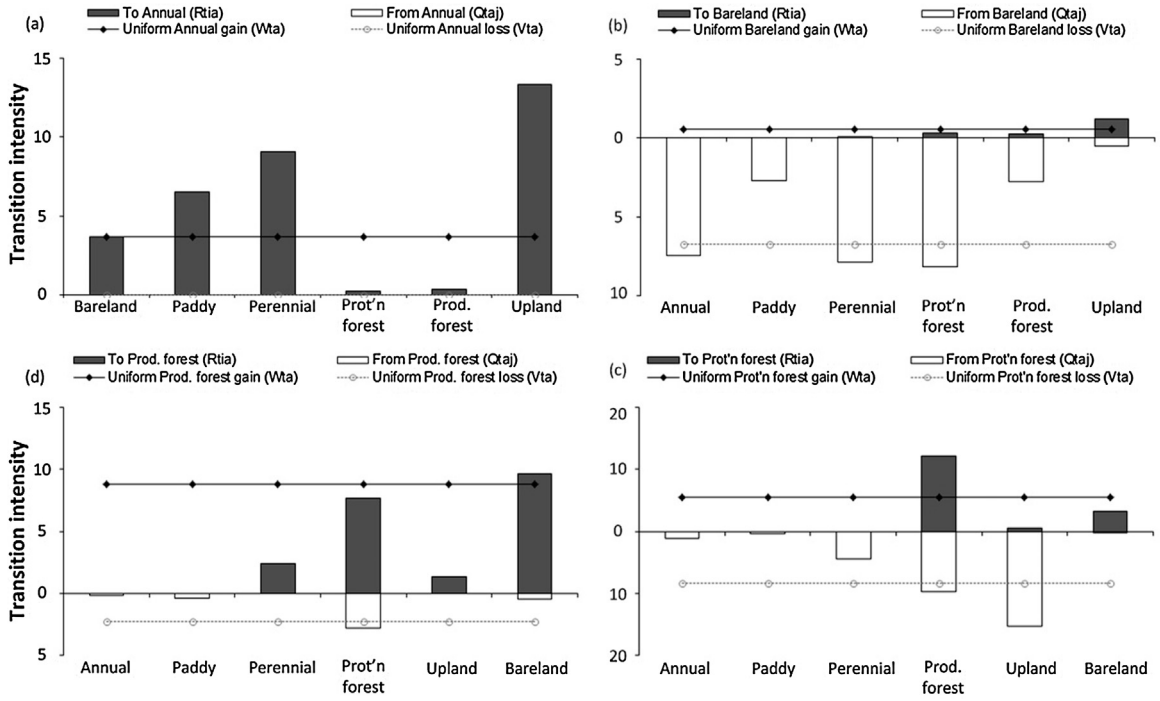

Fig. 3. Key land-use trends from 2005 to 2010 for (a) annual crops, (b) bareland, (c) protection forest (Prot'n), and (d) production (Prod.) forest based on the intensity analysis results (Aldwaik and Pontius, 2012).

whereas production forests and tree plantations increased during the period, 2005–2010. The most common transition pattern was from protection forest to upland crops, and eventually from upland crops to annual crops. There was no indication that forests were being directly converted to annual crops (Fig. 2), which is consistent with the observations of Meyfroidt and Lambin (2008a) that natural forest regeneration was unaffected by increases in rice paddies.

Protection forests were continuously being converted to production forests, which is also consistent with the observed increase in tree plantations associated with declines in natural forest cover in 2000–2005 (Meyfroidt and Lambin, 2008a, 2008b). The observed increase of perennial crops is also likely due to the limited suitability of the area for annual crops (as reported by participants from the men-only RPG groups). The logged forests that are unsuitable for agriculture or upland crops are either left to recuperate or converted to tree plantations.

Upland crops such as swidden rice were replaced by maize or cassava, which reflect the Vietnamese government's perception that swidden rice production is environmentally destructive due to associated use of fire (Van Mai and To, 2015), although this relationship was not captured in the field survey. At the individual level, there was no evidence from the survey results of any disparity between men and women with respect to willingness to change current land uses. Both gender preferred annual crops (approximately 90% of respondents), which is considered the most profitable land use in the study area. The importance of labor availability to the conversion of other land uses to annual crops based on regression analysis, implies that gender difference is implicitly linked to access to communication (number of mobile phones) and existence of agroforestry systems, which were both identified as significant determinants of land-use decisions (Fig. 4).

The association between labor availability and expansion of agricultural areas in northern Vietnam (Meyfroidt and Lambin, 2008a) follows the smallholder agricultural intensification transition pathway described by Meyfroidt and Lambin (2008b) for the entire country. As population increases in the north, more agricultural area is needed, which is reflected by the conversion of production forests. This observation is supported by the fact that the study area is located in the poorest region of Vietnam, wherein food security is primordial to the local residents (Minot, 2006; Nguyen and Lund, 2012). A strong emphasis on food security may likely reduce the multi-functionality of landscapes, however, the limited suitability of some areas to annual crop production, has in turn, limited expansion by households. Consequently, perennial crops and tree plantations will likely remain the dominant land use in the area. For instance, according to a local village officer, one of the reasons for choosing fruit trees over other land uses is water logging in the soil during the rainy season due to construction of the Da hydroelectric dam. Based on the results of the survey, the hypothesis that appreciation of tree-cover varies according to gender does not hold true.

However, in contrast, the RPG results suggest that gender-specific land-use preferences do exist, in that, the hypothesis on differential appreciation of land uses by gender may hold true in some situations. The women-only RPG results revealed the same land-use transition pattern from forest to predominantly annual and perennial crops for both lowland and mid-land elevations, with differences only in the preference for perennial crops (sugarcane) in the lowland elevations, which was consistent with the survey results. In both elevations, there was a decreasing trend in the area of protection forests.

Five of the six female-only groups in both low and mid-land elevations exhibited an increasing trend in the area represented by agroforestry, which serve as a source for food, suggesting that women have a stronger preference for agroforestry than men in the study area. In contrast, the male-only groups in both elevations prefer to have more production and protection forests. Apparently, men were hesitant to change their existing land use to annual crops because they believe that the soil quality in forested areas is not suitable for annual and or perennial crops. These observations are consistent with the findings from Sumatra, Indonesia in a matrilineal context using the same methodological approach (Villamor et al., 2014a) wherein female farmers preferred more profitable crops, while male farmers demonstrated greater awareness of the

Table 3
Household characteristics in the study area, 2013.

Variables/characteristics	Gender	N	Average	Std. Dev	Min	Max
Age	Male	150	44.00	11.90	23.00	80.00
	Female	151	40.00	10.30	20.00	64.00
	Total	301	42.00	11.10	20.00	80.00
Dependency ratio	Male	150	0.18	0.18	0.00	1.00
	Female	151	0.18	0.18	0.00	0.50
	Total	302	0.18	0.18	0.00	1.00
Education (number of year)	Male	150	5.00	1.26	2.00	8.00
	Female	151	5.20	1.36	0.00	8.00
	Total	302	5.00	1.30	0.00	8.00
Labor availability	Male	150	3.60	1.20	1.00	7.00
	Female	151	3.30	1.20	1.00	6.00
	Total	302	3.40	1.20	0.00	7.00
Number of children (#)	Male	151	1.70	0.90	0.00	4.00
	Female	151	1.70	1.18	0.00	11.00
	Total	302	2.00	1.10	0.00	11.00
Household size	Male	151	4.30	1.14	2.00	7.00
	Female	151	4.10	1.26	2.00	7.00
	Total	302	4.00	1.20	0.00	11.00
Landholding (ha)	Male	151	3.90	3.70	0.20	26.00
	Female	151	2.60	2.80	0.04	19.80
	Total	302	3.20	3.40	0.04	26.00
Number of farm plots (#)	Male	151	7.71	3.40	2.00	20.00
	Female	151	7.11	2.80	2.00	14.00
	Total	302	7.00	3.10	2.00	20.00
Mobile phone (#)	Male	151	2.00	1.30	0.00	6.00
	Female	151	1.60	1.20	0.00	5.00
	Total	302	1.80	1.20	0.00	6.00
Paddy rice (ha)	Male	151	0.10	0.16	0.00	0.97
	Female	151	0.10	0.19	0.00	1.10
	Total	302	0.10	0.20	0.00	1.10
Annual crops (ha)	Male	151	1.46	1.11	0.00	6.11
	Female	151	1.14	0.92	0.00	4.10
	Total	302	1.30	1.03	0.00	6.11
Perennial trees (ha)	Male	151	0.32	0.61	0.00	3.00
	Female	151	0.18	0.38	0.00	2.00
	Total	302	0.25	0.51	0.00	3.50
Fallow plots (ha)	Male	151	0.18	0.57	0.00	5.00
	Female	151	0.15	0.39	0.00	3.00
	Total	302	0.16	0.49	0.00	5.00
Agroforest gardens (ha)	Male	151	0.01	0.11	0.00	0.80
	Female	151	0.10	0.16	0.00	1.00
	Total	302	0.10	0.14	0.00	1.00
Forest (ha)	Male	151	1.72	3.14	0.00	18.00
	Female	151	0.91	2.50	0.00	18.00
	Total	302	1.31	2.86	0.00	18,00
Mixed crops (ha)	Male	151	0.09	0.35	0.00	3.20
	Female	151	0.07	0.26	0.00	2.50
	Total	302	0.08	0.31	0.00	3.20
Gross income (1000 vdn)	Male	148	28,883	21,977	1800	123,000
	Female	151	26,771	44,543	1200	518,600
	Total	302	27,541	35,120	1200	518,600

Note: Ten of the variables listed were identified using Varimax normalization of the PCA results with KMO = 0.699.

biophysical aspects of their farms as a factor in decision making. Furthermore, a comparison of the mixed-gender groups with the female- and male-only RPG groups (Fig. 5) suggest that both agroforestry systems and annual crops are preferred by the mixed-gender groups. Because there was no clear indication of a decrease in the area of production forests in the male-only groups, the presence and voice of women in the mixed-gender groups may have contributed to the conversion of production forests to agroforestry and annual crops.

The ambivalent results between the survey and the RPGs suggest the influence of group dynamics in decision-making. In group settings, the individuals have the opportunity to discuss, learn and influence each other, see the broader picture, and better link household and community level benefits, as opposed to one person making a choice (typical in individual interview setting), which promoted the use of 'collective decision-making and planning' approaches by government and non-government organizations. However, several factors need to be considered in facilitating collective decision-making, including asymmetric power relations in

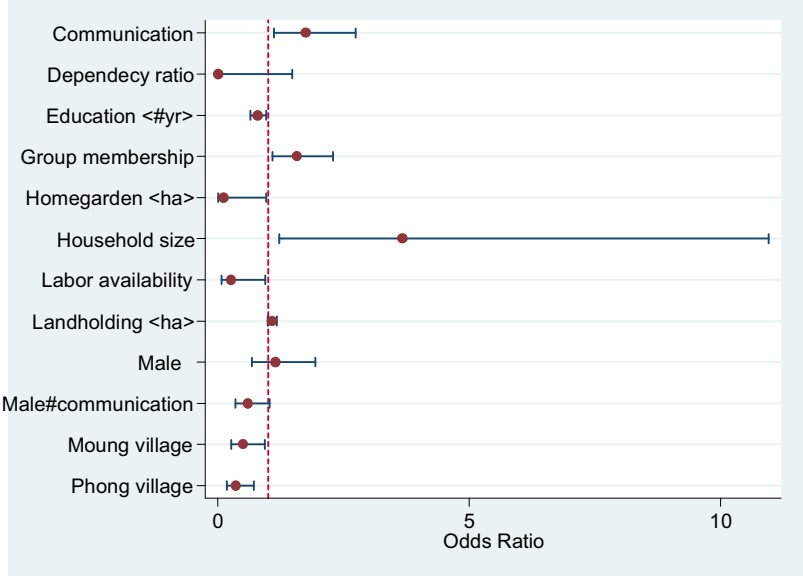

Fig. 4. Variables associated with land-use decisions (N = 302; R^2 = 0.11).

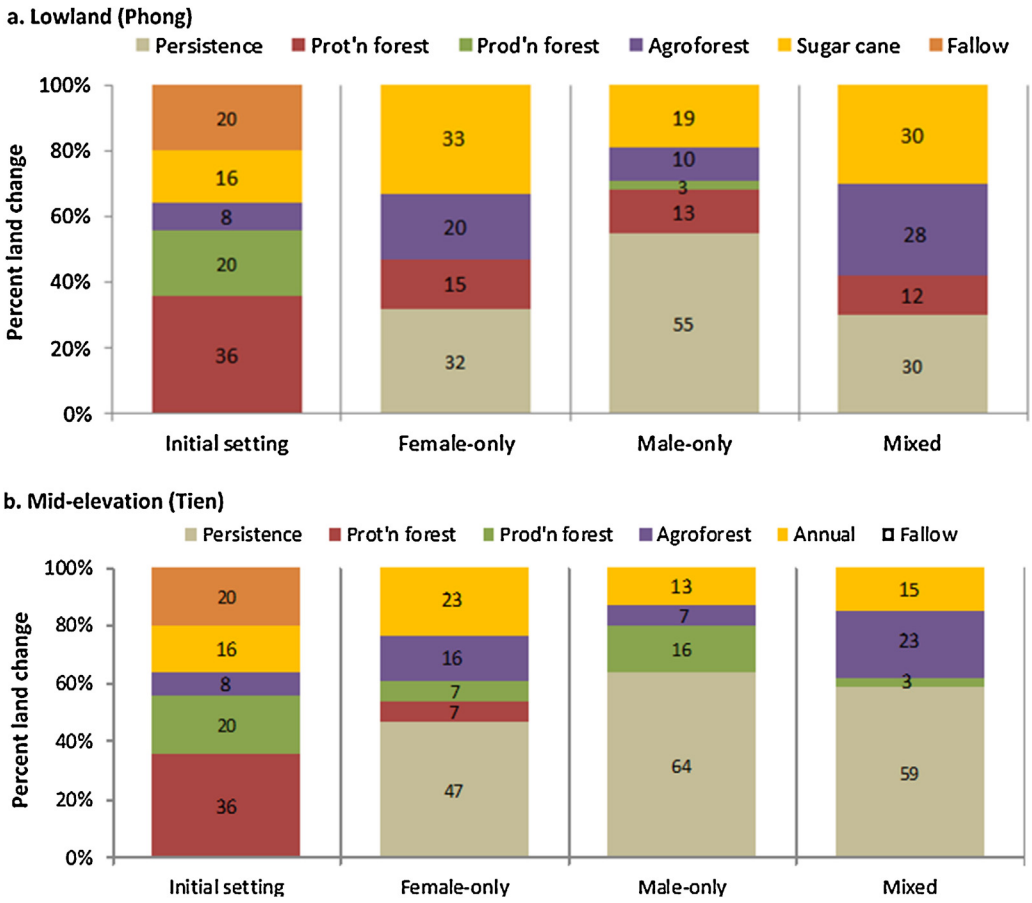

Fig. 5. Gender specific land-use changes in the (a) lowland and (b) mid-elevation areas based on the RPG results.

a group. In our RPGs, we anticipate the possibility of power play in group settings, so they were carefully observed, although this was not the focus of the study.

A supplementary hypothesis in this case, is that institutional change, from a forest protection focus to an agrarian focus on tenure and land-use rights may be needed to support the transition from declining tree-cover area towards increase and recovery (Akiefnawati et al., 2010; van Noordwijk and Villamor, 2014). An example of institutional change is the shift from communal to household ownership of land, defined by the Land Law of 1993. The Law established the land allocation policy in Vietnam and serves as the basis for equitable land allocation (Gordon MacAulay et al., 2006). Under this Law, land is allocated to each household in the northern provinces of the country with a limit of 2 ha for annual

crops, and 10 ha for perennial crops per commune. The duration of land tenure for each household is 20 years for annual crops and 50 years for perennial crops. Because lands are allocated to households, the names of the husband and wife are inscribed in the tenure instrument (*the Red Book*), and they share the same plots for their livelihoods. This particular provision of the Law helps explain the strong similarity in individual perspectives of men and women, with regards to land use change and land use decisions. We posited that this policy further promoted the egalitarian norms of Vietnamese households embedded in a socialist governance system. Several other studies have documented how institutional change has positively affected land tenure and rural livelihoods in Vietnam (Castella et al., 2007; Gordon MacAulay et al., 2006; Lambin and Meyfroidt, 2011; Meyfroidt and Lambin, 2008a, 2008b)

4.2. Agroforestry systems: a tree-based system that promotes gender balance

Agroforestry is one of the dominant tree-based land uses in the mixed-gender RPGs. In the context of landscape multifunctionality, agroforestry provides a wide spectrum of ecosystem services in addition to the provision of food and fruits for household subsistence purposes (Jose, 2009; Swift et al., 2004). During the RPGs, the women emphasized the importance of agroforestry products for household subsistence, whereas the men highlighted long-term benefits such as timber. The mixed-gender RPG groups maintained areas of protection forests together with agroforestry systems, which could enhance the value of important ecosystem functions such as the pollination of fruit trees (Tscharntke et al., 2011). This suggests that if a transition towards greater multi-functionality in the landscape is desirable, both men and women should be involved in land-use decision making so that their individual motivations are heard, and both their preferences are considered.

The results of the mixed-gender RPG were similar to the female-only group in the lowland site, whereas the mixed-gender group outputs from the mid-elevation site were similar to the male-only group output (Fig. 5). This result is predictable because annual crop production (a land use preferred by women) dominates the lowland areas. In steeply sloping areas, land uses that provide tree-cover, which are preferred among men for their function as buffer against soil erosion, are more common

Although the land-use pattern of the mixed-gender RPG groups are not directly comparable to the actual land-use pattern in the study area (Table 1), the household survey data suggests that it would be possible to coordinate both men and women when it comes to making land-use decisions. This corroborates with the findings of Catacutan and Villamor's (2016) study of gender roles in the same study area, wherein they found that most of the households' productive and reproductive activities are jointly shared by men and women. When it comes to decision-making, men and women (husband and wife) typically consult each other before making important decisions. These observations suggest that egalitarianism in the context of Vietnam's socialist regime may have contributed to gender equity at the household level. This aspect of achieving gender equity merits further investigation.

4.3. Lessons learned

The mix-method approach was useful in exploring gender-specific differences in land-use preferences. Although no clear distinction in land-use preferences between men and women was identified from the household survey data or land-use intensity analysis, the RPG revealed some differences in motivations and preferences between genders. The mixed- gender RPG groups identified a tree-cover land-use type (i.e., agroforestry systems) that was not explicitly described in existing land-use maps. The comparison of male- and female-only groups with mixed-gender groups was beneficial to highlight this important difference. Similar studies that included mixed groups of men and women found that combined gender scenarios were more effective for exploiting the strengths of men and women, while tempering their respective shortcomings (Mwangi et al., 2011), where both genders tend to engage in functional and effective partnerships (Sultana and Thompson, 2008). Further, it should be noted that individual land-use decisions change when in the group setting. This observation was also found in the case of Sumatra (Villamor et al., 2014a), wherein individual decisions differed in group settings, and supported by Macy and Willer (2002) that societal patterns emerge from purposive choices and not from social facts external to individuals.

Considering the role of gender in tree-cover transition, agroforestry would be a good option for both men and women because it simultaneously provides ecosystem services and livelihood benefits, and both genders appear to be aware of these dual benefits (Table 3).

There were some challenges encountered in understanding the relationship between gender specific land-use preferences and the pattern of tree-cover transition, which limited the study. First is the classification of agroforestry as a land use–this is an issue identified by respondents during the household survey and the RPGs, since 'agroforestry' is not distinguished in the 2005 and 2010 land-use maps (Table 1). The reason for this discrepancy appears to be that the sizes of agroforestry plots are too small to be captured in land-use mapping, but failure to recognize this important land use by policy makers or government agencies could create conflict in the future. Another limitation of this study is its lack of focus on intra-household and intra-gender group power relations, which could affect the dynamics of land-use decision-making. In this study, we focused on land use preferences of men and women individually, as well as preferences in segregated and mixed gender groups.

5. Conclusions

Understanding tree-cover transition in northern Vietnam using a mix-method approach to generate meaningful insights on gender-specific land-use preferences and decisions is important to foretell future land-use changes. There was no direct indication that gender-specific preferences affected the historical tree-cover transition pattern in northern Vietnam. Furthermore, the differences between genders with respect to the probability of converting current land uses were not significant, with both expressing interest in changing current land uses should the opportunity arise. Because of higher profitability, annual crops is individually preferred by men and women, although expansion is hampered by labor availability; however land-use preference changed in group settings, indicating the linkages between individual and group preferences, and further implying that landscape level decisions maybe better formulated through participatory approaches and consensus building processes. It appears that, agroforestry is a land-use option that appeals to both genders as it addresses their respective needs. Ultimately, if a landscape is deemed desirable for current and future use, the land-use preferences and decision-making tendencies of both men and women should be taken into account in land use planning and investments by relevant authorities.

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