Title

Coupling local perspectives with remotely sensed data to better understand small-scale tropical forest changes

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Abstract

Forests are essential for climate, biodiversity and society. Conserving or increasing forest cover is the focus of many national and international policies. Yet implementing such policies at local levels remains a massive challenge, in part due to contrasting perceptions of small-scale forest cover changes and their effects on livelihoods. In this study, we couple remotely sensed forest cover changes at the village-level with local perceptions of land-use changes between 2010-2020 and their drivers. Our focus is on the Lao People's Democratic Republic (Laos) which has set a national goal of increasing forest cover to 70%. We conducted focus group discussions and walking interviews with village committees in 27 villages in the province of Vientiane and Vientiane capital. We find that remote sensing data and the perception of village committees align on negative forest cover trends at small scales. The village committees expressed that current economic, policy and socio-economic drivers are more likely to lead to the maintenance or expansion of agricultural areas, rather than to the conservation of forests. As future developments, the village committees prioritize infrastructure and socio-economic development over forest conservation. Our findings highlight the importance of a context-specific understanding of forest cover changes. More just and effective forest policies can be formulated by coupling local perspectives with remote sensing in landscape planning. Ultimately, this study illustrates that forest cover-changes are complex, contentious, and require participatory and adaptive policy responses that reflect this reality.

Keywords

Forest conservation; local perceptions; remote sensing; landscape planning; forest policy; Laos

Statement

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1. Introduction

Tropical forests are undergoing rapid transformations. The reduction of natural tropical forest results in depleting carbon stocks (Baccini et al. 2017) and biodiversity loss is among the highest in the world (Sodhi et al. 2010). The forest cover loss further compromises the contributions of forest to people (Estoque et al. 2019). Many national and international policies aim at conserving or restoring tropical forests. The implicit underlying assumption is that more forests increase ecological regeneration and human wellbeing, and therefore leads to sustainable development (Kull et al. 2024). To counteract the current trends, policies typically support afforestation as part of a 'forest transition'; a shift from net deforestation to net reforestation (Rudel et al. 2016). Policy targets are mainly based on tree cover (e.g. the Bonn Challenge) or biomass (e.g. carbon markets). To measure and monitor the policies' effects, large-scale landscape assessments relying on remote sensing data are applied (Keenan et al. 2015). Forest cover and restoration potential based on remote sensing data alone can however lead to over- or underestimation (Fesenmyer et al. 2025). Policies based on distorted forest estimates run the risk of misaligning with local contexts and negatively affecting livelihoods (ibid). Hence, to understand what or if value is brought to local people and biodiversity, large-scale assessments are not sufficient (Mansourian et al. 2017). Despite evidence that including local communities enhances decision-making and helps inform more effective and just policies, local perspectives on forest changes are rarely considered to complement large-scale assessments (Erbaugh et al. 2020; Waeber et al. 2023).

The Lao People's Democratic Republic (Laos) has seen important recent forest cover loss, reflecting broader trends in Southeast Asia, which experienced unprecedented deforestation between 1990 and 2015 due to anthropogenic impacts (Keenan et al. 2015). In Laos, in the 1960s, forest was estimated to cover 70% of the total country area, but then decreased to 41.5% by 2005 according to national statistics (Government of Laos 2005). Due to growing concerns on adverse social, economic and environmental impacts, the Laos national Forestry Strategy set the goal to increase forest cover to 70% by 2020 (Government of Laos 2005), which was renewed in 2024 (Government of Laos 2024). To combine national goals for socio-economic development, poverty eradication and environmental conservation, the government pursued a strategy of land use segregation, designating land for economic development and land for conservation (Castella et al. 2013). At the same time, policies were designed to attract companies and private investors (Kenney-Lazar et al. 2018). In 2020, the Lao government reported a forest cover of 72.1% of total country area to the Global Forest Resources Assessment based on a national-scale remote sensing assessment (FAO 2020). In 2024, the government has corrected this number to 62% forest cover (Government of Laos 2024). Both numbers suggest that their policies have succeeded in achieving a forest transition. Yet it remains unclear how forest changes played out at the local scale, and how these changes are perceived by local communities. While there are studies on forest changes in Laos with remote sensing data (Chen et al. 2023a, b), there is a lack of studies that couple this data with local perspectives.

Here, we integrate local perceptions with remote sensing data to assess forest changes and their drivers at the village community level. To do so, it is essential to understand the broader context of land-use changes, as they are directly related to forest loss and gain. We assess local perceptions on land-use changes in Lao villages and link them with remote sensing data, as indicators for observed land-use changes between 2010-2020. We analyze the perceived drivers of land-use change qualitatively and assess the local priorities for future developments to contribute to an understanding of the impacts of forest changes on people and nature. Our research is guided by the question: How are land-use changes and their drivers perceived by local communities in the context of forest conservation and socio-economic development? By highlighting the importance of local perspectives, the study offers novel insights into the alignment of national forest conservation policies and local

priorities, and contributes to acknowledging socio-economic and environmental trade-offs as enablers of forest transitions.

2. Methods

2.1. Case study region

We collected data in the provinces of Vientiane and Vientiane capital in Laos. 55-80% of households in Vientiane province and 30-55% of households in Vientiane capital province practice agriculture for subsistence and as the main income source (Epprecht et al. 2018). Vientiane capital is the largest urban center in the region and growing rapidly; the urban area has increased more than twofold since 2000 (Huang and Zhang 2022). Furthermore, large-scale infrastructure is under development, such as a new expressway and railway (Vörös & Somsack, 2020).

We collected data in June and July 2023. We randomly selected 27 villages in the study area, stratified by different degrees of accessibility, using a global dataset of travel time to cities (Weiss et al. 2018), and by predominant land cover, using an aggregated raster dataset at 30 meters resolution (Chen et al. 2023a). We sampled villages from the Laos country OpenStreetMap dataset (Geofabrik GmbH 2023). For logistic reasons, in three cases we could not visit the pre-sampled locations but chose another nearby village as alternative.

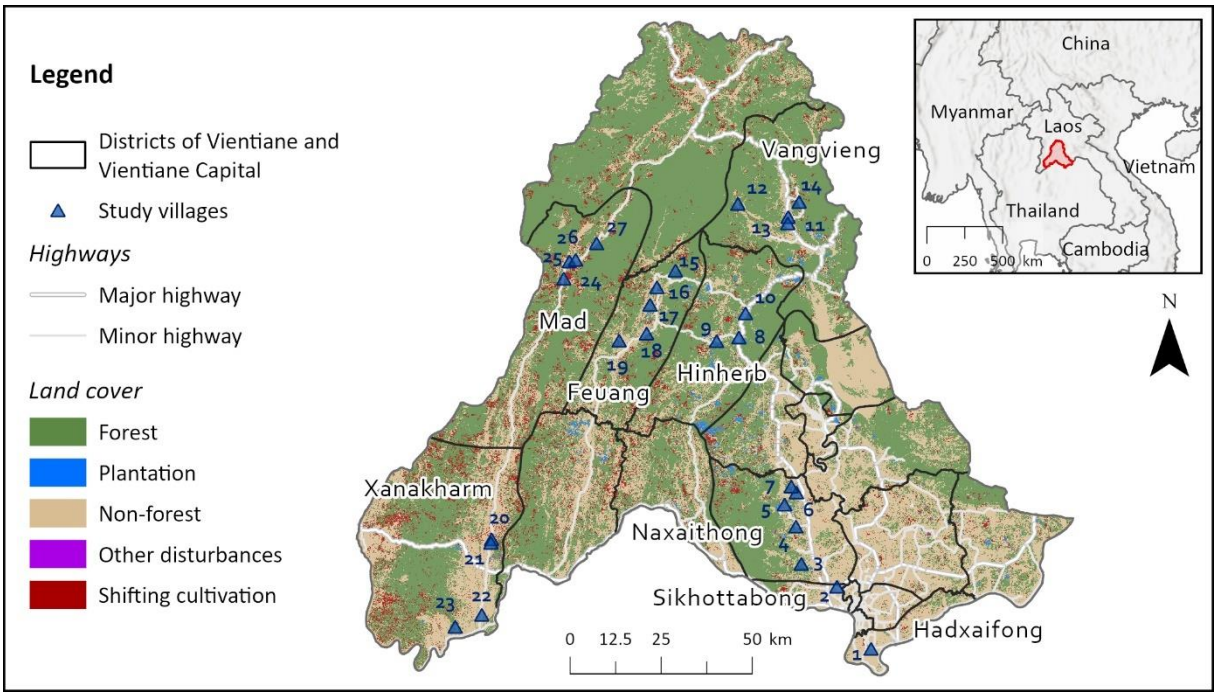


Figure 1 Case study area with 27 study villages across eight districts in Vientiane and Vientiane Capital province. Background colors show land cover in 2020 (Chen et al. 2023a), road infrastructure (white lines) and administrative boundaries (black lines).

2.2. Remote sensing data and analysis

We used the land cover-change time series raster dataset based on Landsat from Chen et al. (2023a) to analyze land cover-changes in the case study region. For our analysis, we used the publicly available annual maps for each year between 2010 and 2020. The annual maps feature eight categories which we simplified to five, by reclassifying *disturbances, severe drought* and *deforestation* into *other disturbances*, and summarizing *plantation* and *new plantation* into *plantation,* while keeping the categories *forest, non-forest, shifting cultivation* unchanged. We computed the land cover-changes for each village from the reclassified dataset in ArcGIS Pro by applying a circular buffer of 4 kilometers

around each village. The distance was selected as it was the maximum distance covered in the field walks which were representative of the area of direct interest to the village communities. Within the buffer, we calculated the number of pixels for each category and year.

2.3. Focus group discussion and walking interview

To explore local perceptions of land-use changes, we conducted a pilot phase of ranking exercises, followed by focus group discussions and walking interviews with village committees (Figure 2). Focus group discussions allow us to capture different perspectives of the participants (Hennink 2007) while walking interviews provided place-specific insights into a local communities' connections to their environment (Evans and Jones 2011). Members of the village committees were typically the village head and vice head(s), as well as representatives of the Lao People's Revolutionary Party and representatives of village unions (e.g. Elder's Union, Women's Union). They are often long-term residents and well-informed about developments in their village. The number of participants ranged between 2-12 (mean 5.3) people. 71% of the participants identified as men, and 29% as women. We held the discussions and interviews in Lao and co-author KN translated between Lao and English. The conversations were audio recorded, and main points protocoled during and after the sessions.

In the pilot phase, we applied a participatory bottom-up approach to ensure that the selection of land uses was grounded in local perceptions (Reed 2008). In the first four villages, we asked village committees to list landscape elements within their village administrative boundaries and to rate their importance in terms of income and livelihood. Based on frequency and rank, we selected the twelve most relevant land uses to be applied in subsequent focus groups: paddy fields, pasture, fruit and vegetable fields, home garden, cassava fields, rubber plantation, teak plantation, conservation/protection forest, production forest, sacred forest, cemetery, and river/fishponds. In the discussions, we talked about *forest for water and biodiversity* instead of conservation/protection forest, and *forest for fire wood, construction wood, and food* instead of production forest. Also, sacred forests and cemetery were often the same areas. We revisited the pilot phase villages at a later point in time to collect additional data after having visited all other villages.

In the focus groups, we asked the village committees to describe area change of the previously identified land uses between 2010 and the date of data collection (Figure 2). For each, we noted whether it was present in the village and, if so, whether its area had increased, decreased, or remained unchanged; absence was also recorded. We asked for the reason behind the trends, eg. "*why is the paddy area decreasing?"*, and about the previous or next land use, eg. "*what is the paddy area used as now?".* Lastly, we asked participants to list the main changes in the village since 2010 and developments they wished to see in the future. These concluding questions were posed in an open-ended manner, not confined solely to land use-changes.

The walking interviews took place after the focus groups. Guided by 1–4 participants, we explored areas highlighted by the focus group as interesting (e.g., those affected by recent land use changes), as well as locations chosen by participants in village vicinity.

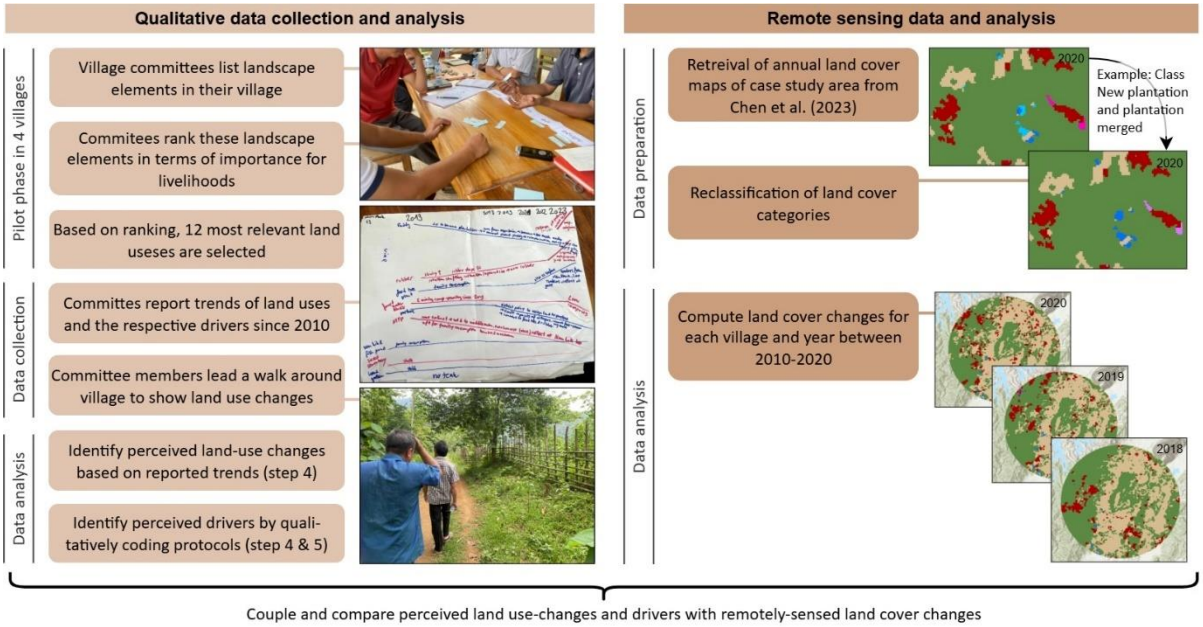


Figure 2 Data collection and analysis illustrated with pictures from focus group discussions and walking interviews, and screenshots from data processing in ArcGIS Pro.

2.4. Qualitative data analysis

The perceived land use-changes between 2010 and 2020 were coded from the trends of the twelve land uses reported in the focus groups: either increasing, decreasing, no change, or the land use is not present in the village.

The perceived drivers of land use-changes were identified in focus groups and walking interviews. To identify common drivers, we qualitatively analyzed the focus group protocols in the software MaxQDA (VERBI Software 2021). The analytical approach combined elements of induction and literature-based coding (Deterding and Waters 2018). The coding procedure was as follows: If village committees perceived a land use to change, we applied a code to the respective statement about the direction of conversion (e.g., from forest to agricultural land). If the coded statement further contained a specific driver for the change, it was assigned to a group of codes where similar reasons were given (e.g., forest is converted to agricultural land because agriculture makes a good income). This way, the coded statements were organized based on common drivers. The drivers are then further summarized into political, economic and socioeconomic (Rudel et al. 2005; Lambin and Meyfroidt 2010; Meyfroidt et al. 2018). We counted the number of coded statements for each driver, distinguishing the different conversion types. In doing so, we showed which perceived drivers are associated with which perceived land use-changes.

3. Results

3.1. Forest cover development

Land cover classification based on remote sensing data reveals that the proportion of forest cover varies considerably between villages (Figure 3). In the Vientiane city outskirts, Village 1 and 2 have a forest cover proportion of 4.2% and 6.3% in 2010. Their village committees report to not have forest within their administrative boundaries. The district with the highest proportion of forest cover at the beginning of the study period is Mad (87.4% for village 24, 73.3% for village 25, 73.9% for village 26 and 88.0% for village 27). Equally, village 15 in Feuang (87.4%), village 12 (85.7%) and 14 (82.0%) in Vang Vieng, and villages 8 (77.4%), 9 (78.9%) and 10 (78.4%) in Hin Heup do have a forest cover proportion over 70% in 2010.

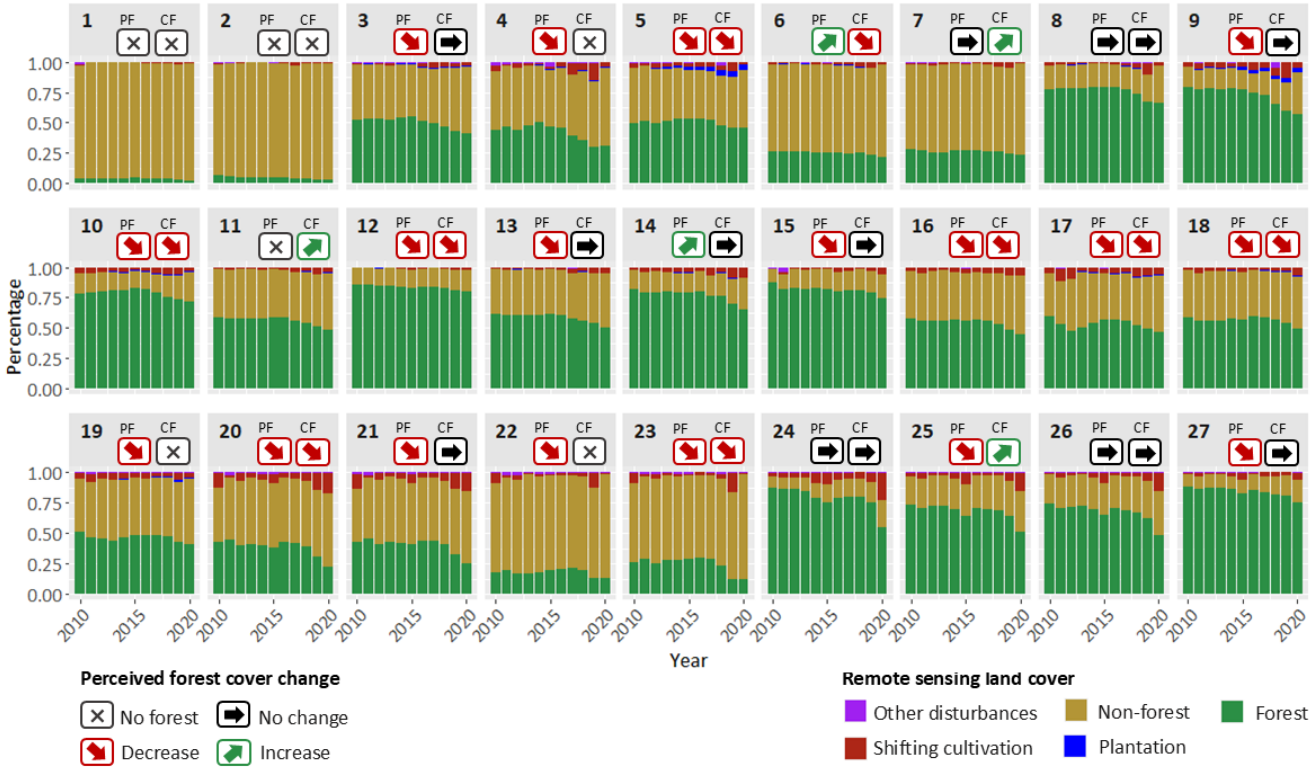


Figure 3: Comparative assessment of observed and perceived forest cover changes in the vicinities of 27 villages (village numbers in bold). The land cover-changes classified by remote sensing between 2010-2020 are shown in the bar plots. The perceived forest cover trends by each respective village committee are shown with arrows in the top of each panel and are shown separately for production forest (PF) and conservation/protection forest (CF).

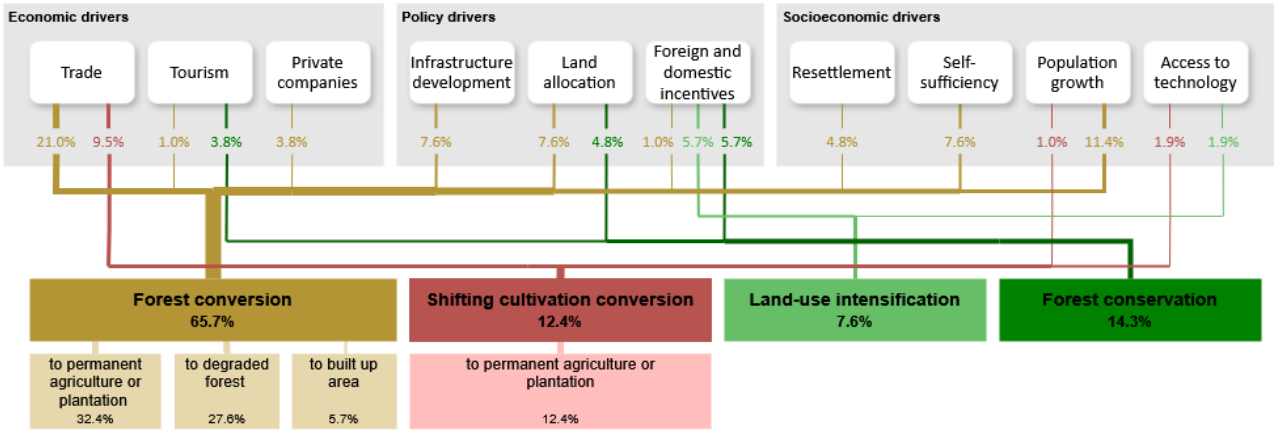
We find a forest cover reduction in all villages during the study period based on remote sensing (Figure 3). The largest relative forest cover reductions occur in Mad district. We find a reduction of 32.8% in village 24, a reduction of 22.6% in village 25, 25.4% in village 26 and 12.5% in village 27, respectively. Further, village 9 in Hin Heup (-21.81%) and village 20 in Xanakharm (-20.81%) show forest cover reductions larger than 20%. The smallest forest cover reductions below 5% from villages with forest within their administrative boundaries are found in the urbanized Vientiane capital area of village 5 (-3.93%), village 6 (-4.29%) and village 7 (-4.96%), as well as in village 22 (-4.47%) in Xanakaharm.

In focus group discussions, most village committees perceive the forest cover to have decreased. From the villages with production forests within their administrative boundaries, 75% perceive it to be decreasing, and 25% of villages perceive the forest to be stable or increasing. Less villages perceive the conservation/protection forest as decreasing. Of the villages with conservation/protection forest

within their administrative boundaries, 40.9% perceive a decrease, 45.5% perceive it to be stable and 13.6% as increasing. Notably, the perception of village committees and the results from remote sensing differ in villages with the largest remotely sensed forest cover reductions (village 9, 24, 25, 26, 27). These villages report stable or increasing production or conservation/protection forest, only village 9, 25 and 27 perceive the production forest to decrease.

3.2. Perceived drivers forest cover change

From the qualitative coding analysis of the focus group discussions and walking interviews, we synthesize ten drivers of land use-change (Figure 4). We classify *trade*, *tourism*, and *private companies* as economic drivers. *Infrastructure development*, *land allocation policies*, and *domestic and foreign incentives for forest conservation* are identified as policy drivers; *resettlement, population growth, self-sufficiency* and *access to technologies* as sociodemographic drivers. All ten drivers are perceived by village committees to lead to forest conversion or degradation in some way. Yet three drivers are also associated with forest conservation: *foreign and domestic incentives, land allocation policies* and *tourism*. Some village committees associate the drivers *foreign and domestic incentives* and *access to technology* with agricultural intensification. As the village committees do not specify whether intensification led to less forest loss, these statements are not counted toward forest conservation.



	Economic drivers			Policy drivers			Socio-economic drivers			
	Trade	Private Company	Tourism	Infrastructure development	Land allocation	Foreign and domestic incentives	Resettlement	Self-sufficiency	Population growth	Access to technology
Forest to permanent agriculture or plantation	12	1	0	1	8	1	3	3	5	0
Forest degradation	10	0	0	6	0	0	2	5	6	0
Forest to built-up area	0	3	1	1	0	0	0	0	1	0
Shifting cultivation to permanent agriculture or plantation	10	0	0	0	0	0	0	0	1	2
Land-use intensification	0	0	0	0	0	6	0	0	0	2
Forest conservation	0	0	4	0	5	6	0	0	0	0

Figure 4 Perceived drivers of land use-change in the case study area and their frequency of being mentioned by village committees in focus groups. The table shows the frequencies of how often each driver and land use-change outcome is mentioned in relation to the total number of coded statements (total of 105 statements). The flowchart on top is based on the table and visualizes these frequencies and their associated land use changes proportionally.

65.7% of all statements are associated with forest conversion: Of which, 32.4% refer to conversion to permanent to agriculture or plantations, 5.7% refer to conversion built-up area, and 27.6% to forest degradation. Additionally, 12.4% of statements are associated with conversions of shifting cultivation to permanent fields. *Trade* is the most commonly stated driver of forest conversion, mentioned in 21.0% of all statements. Village committees describe how increased visits of traders lead to higher demand for agricultural products and land use conversion, as highlighted in this exemplary quote:

"Around 20 years ago, we had to expand our cultivation area for the cash crop *job's tears* [perennial grass crop grown native in Southeast Asia that is cultivated for both its edible, pearl-like grain]. At that time, we primarily sold *job's tears* to traders from Thailand. However, when China discovered that the *job's tears* they were buying originated from Laos, Chinese traders began purchasing directly from us. Now there is a *job's tears* pest, so we plant cassava on these plots." Village 20 (V20)

Population growth is the second most commonly stated driver of forest conversion and degradation (11.4% of statements). Together with *self-sufficiency* (7.6%), these drivers show the land pressure that stems from demographic shifts:

"The non-timber forest products (NTFPs), firewood and construction wood are overharvested. The population growth increases the pressure on the forest, people also go to the protected area for collection. There are also misbehaving households who invade the forest to grow upland rice [representing shifting cultivation]. We are not happy about [forest] decrease and worry that there will not be enough for future generations. The plan is now to grow NTFPs ourselves, so we become less dependent on the forest" V5

Infrastructure development as a driver of forest conversion and degradation is mentioned in 7.6% of statements. In most focus groups, development means new roads or road improvements, but also hydropower plants or mining sites were reported to impact the forest. New or improved roads are said to facilitate access to forests and cut trees. Transport infrastructure development was perceived to facilitate trade:

"Now we have good road conditions which means we can sell our products in time before they rot. We travel to the Vientiane market and back in a day. This is why people can increase the fruit and vegetables productions in the home gardens." V23

14.3% of all statements are associated with forest conservation. *Foreign and domestic incentives* are the most commonly stated driver of forest conservation, mentioned in 5.7% of statements. Forest conservation initiatives are found to mostly target villages where forest cover is still high. The village committees name incentives such as national tree planting programs or programs funded by multilateral organizations:

"We share the protection forest with another village. Due to a sustainable management project with foreigners, we planted new trees. The project disseminated knowledge how to protect the forest from fire and distributed seedlings" V11

Some programs supported the village budget, which is perceived as a main advantage, because it allowed the villages to make investments, such as in agricultural training courses and new technologies. These in turn can help villages to rely less on trading forest and agricultural products as an income source.

"We want to get more budget to support training and technology for frog nurseries and greenhouses. These activities should become the main income source." V7

Effective *land allocation policies* as a driver of forest conservation are mentioned in 4.8% of all statements. Land allocation policies are however even frequently reported to be unable to halt land conversion (7.6%). In some villages, local administrations are found to illicitly issue land titles in protected areas.

"The national protected area is heavily invaded for cassava and rubber. Our village does not invade but maybe other villages around here know more. The villages handle problems once

they arise and do not inform the district about land conversions. Once a year however there is a procedure with the district government to see whether those who have invaded the forests have to be punished." V6

The least commonly stated driver of forest conservation is *tourism* (3.8% of all statements). Tourism is seen as a good income source. Village committees perceive nature to be an attractor of tourists which is why its conservation is important.

"Shops and services for tourists bring a better and more stable income than agriculture. The infrastructure development and better accessibility will bring more people here and the locals see the potential to make a good income from it. To attract tourists, it is important that we are a green district and educate the youth about the importance of the conservation forest." V11

Due to the growing numbers of visitors and the need for guesthouses however, village committees also report to convert forest to built-up areas (1.0%).

3.3. Past and desired future developments

The main priorities of village committees for future development mentioned during focus group discussions are infrastructure and socioeconomic development (Figure 5). The most frequently desired development is the improvement of the road network which is mentioned in 14 focus groups out of 27. This includes the improvement of national, provincial and district roads, as well as paving local roads in the villages. New agricultural techniques, such as training in how to apply fertilizer or access to better machinery is the second highest priority, mentioned in 9 groups. Priority is further given to education, which is mentioned in 8 focus groups. Alternative income sources such as income from factories (4 groups) or tourism (2 groups) are also desired in the future. Forest conservation was never mentioned as a priority for future village development.

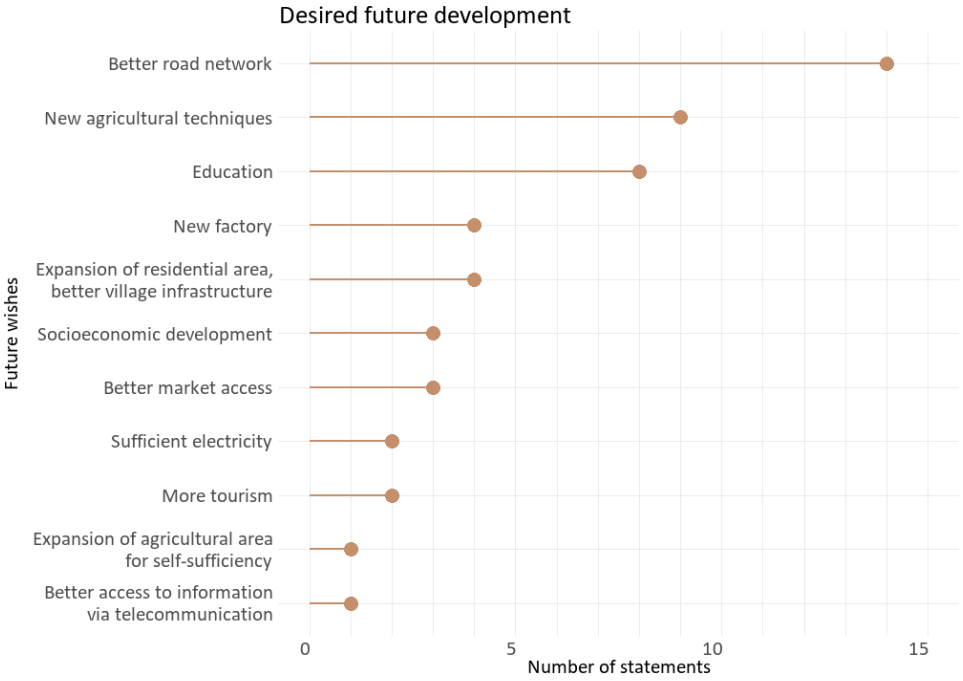


Figure 5 Frequency of future desired developments mentioned in the focus groups. Note that the number of statements varies between villages because the discussions differed in length and detail

4. Discussion

By integrating local perceptions from focus group discussions and walking interviews with remote sensing data, this study applies a novel mixed-methods approach to investigate land use-changes and their drivers around villages along a gradient of accessibility from peri-urban to rural. We find that village committees widely align with remote sensing data on a negative forest cover trend at small scales. Assessing the perceived drivers of land use-changes reveals that there are few drivers fostering forest conservation, and the majority of drivers lead to loss of forests or loss of shifting cultivation areas. Furthermore, we find that village committees do not prioritize forest conservation as part of their desired future development.

4.1. Alignment between local perceptions and remotely-sensed data

The remote sensing analysis and the local perceptions align on decreasing forest cover at the village level. This is in line with other participatory case studies conducted on local or regional scales in Laos (i.e., on similar scales as our analysis) that also found ongoing forest cover loss (Hepp et al. 2021; Castella and Phaipasith 2021; Latthachack et al. 2023). We find a strong alignment between the perceived loss of production forest and trends shown through remote sensing time series for the vicinity of villages. Indeed, forest cover losses are typically high within villages and their close surroundings, as it has been documented for South Asia overall (Ahammad et al. 2019).

The alignment between perceived and remotely sensed forest cover changes indicates that remote sensing data is an accurate base for forest cover change assessments at the village level. Typically, remote sensing studies, including those for Laos, have been conducted at the regional or national level (Tang et al. 2019; Mermoz et al. 2021; Chen et al. 2023a, b). Our study demonstrates that remote sensing can also provide valuable information at smaller scales, opening new opportunities for its integration into local landscape planning. We use remote sensing data with relatively high spatial (30m) and temporal resolution (annual) (Chen et al. 2023a) which was not available for Laos until recently. Such high-resolution remote sensing data is needed to analyze land cover-changes in very dynamic and heterogeneous landscapes (Miettinen et al. 2014). However, to not only infer land cover but land use, data with even higher resolution is often required. Moreover, remote sensing data remains limited in tropical regions due to frequent cloud cover, and the accuracy of the data depends on the quality of the classification algorithms and the thresholds used to distinguish land cover classes (Mathur and Bhattacharya 2024). Therefore, complementary approaches such as participatory mapping (Zaehringer et al. 2018) remain highly relevant. This is underscored by the discrepancies between the broad land cover classes in the remotely-sensed data and the detailed knowledge about land-uses of the village committees. While local perspectives help to inform large-scale remote sensing assessments, it is equally important to make remote sensing data and capabilites available to local communities (Huang et al. 2025). By being well-informed about local land use-changes, local communities can better participate in landscape decision-making processes.

4.2. Agricultural expansion outpacing forest conservation

Our findings indicate that at the village level, agricultural expansion is ongoing, to the detriment of forest conservation. Economic, policy and socio-economic drivers are perceived locally to more often contribute to the maintenance or expansion of agricultural areas, rather than to forest conservation. At the same time, village committees mention only few drivers of forest conservation that in addition only lead to conservation under certain circumstances. This is remarkable given that Lao land use and development policies assume an ongoing forest transition alongside agricultural intensification and economic development (Castella et al. 2013). In practice, however, evidence from Northern Laos shows that local authorities frequently prioritize agricultural expansion over forest conservation as a poverty reduction strategy (Vongvisouk et al. 2016). The high influence of commercial crop production

is also reflected in our findings, as village committees mention trade as a common driver of forest conversion. In our study area, the impacts of trade are intertwined with infrastructure development: better market access and agricultural commercialization accelerate cash crop production and timber logging. Such circumstances have been described before in Laos (Thongmanivong et al. 2009; Vongvisouk et al. 2014; Hepp et al. 2021; Castella and Phaipasith 2021; Latthachack et al. 2023). When illuminating the effects of commercialization and trade, scholars have often highlighted the increasing number of large-scale land acquisitions in Laos, often from foreign investors (Hett et al. 2017; Nanhthavong et al. 2020; Magliocca et al. 2022; Kenney-Lazar et al. 2023). In this study, village committees addressed related topics. Several committees mentioned the establishment of private companies with associated plantations, or resettlement due to land development projects such as hydropower, transport or tourist infrastructure.

Some of the identified current drivers of forest loss may support reforestation under certain conditions in the longer term. We observed cases where land allocation policies were effective, when participants were aware of rules and fines for invading conserved areas. Furthermore, in some villages, tourism and domestic or foreign incentives provided alternative income sources, which reduced the reliance on forests for income and subsistence. Better infrastructure can also contribute to forest recovery by enabling agricultural intensification, improving forest management profitability, reducing dependence on fuelwood, or lead to rural out-migration, which can reduce pressure on land and forest (Lambin and Meyfroidt 2010; Kaczan 2020).

4.3. High priority for infrastructure development - no forest transition yet

Our findings suggest that, at the village level, Laos is currently not undergoing a forest transition; and that this largely aligns with the preferred future developments of the village committees. None of the committees identified forest conservation as a development priority, even though many expressed concerns about declining forest cover. They consistently prioritized infrastructure and socio-economic improvements: better roads, increased agricultural productivity, and more diverse income opportunities. Similar as shown for rural contexts in Cambodia, infrastructure development can be considered a precursor for forest transitions and aiming for both at the same time is inherently difficult (Riggs et al. 2020a, b). Such local complexities and realities must be acknowledged in forest discourses (Bull et al. 2018). The inclusion and prioritization of local perspectives is key when navigating trade-offs between forest conservation and economic development (Erbaugh et al. 2020; Fleischman et al. 2022). To help shape policies that benefit both nature and people, a thorough understanding of small-scale forest changes and their drivers is important (Martin et al. 2023). Thus, to improve equity and effectiveness of forest restoration, participatory approaches and adaptive management are required (Löfqvist et al. 2023).

What becomes clear from our findings is that forest transitions rarely unfold neatly and predictably, but are ambiguous and context-specific processes. Socially and economically just transitions might not go hand in hand with growing or conserving forests (Kull et al. 2024). Our findings thus underline that more forest does not automatically accompany sustainable development, an assumption that prevails in many national and international forest management policies (Nambiar 2019).

4.4. Methodological advances and limitations

A key contribution of this study lies in its bottom-up approach to understanding land use-change. Much of the existing literature relies on remote sensing analyses and infers drivers of land use-change without getting the perspectives from the ground. Our study reverses this approach by first engaging directly with local communities. We assess whether their perceptions align with remote sensing analyses, which we partly find to be the case at the village scale; and with global narratives from policy and science about forest transitions, which align less well. Furthermore, this approach allowed us to

derive drivers of land use-change rooted in local perspectives (Figure 4), providing a valuable contribution to existing land-use change literature (Geist and Lambin 2002) and policy-making (Hosonuma et al. 2012). Our approach highlights the value of community-based analyses, offering a perspective that remains scarce yet highly demanded in land system science and forest restoration (Benra et al. 2024), adding a nuanced and contextualized understanding of the often top-down derived insights from remote sensing and national policies.

We acknowledge the limitations that arise from basing our analysis on local perceptions. The outcomes of focus group discussions might not represent the overall community perception, participants may not remember past events accurately, and questions can be interpreted differently (e.g. desired future developments may be interpreted from an economic perspective, and not holistically) (Hopkins 2007). Village committees may withhold information on land use-change, as some activities are illegal. It is further important to recognize that the remote sensing data is not directly comparable to the qualitative data collected in the villages. Future research could improve the resolution of remote sensing data, engage with diverse stakeholders and expand the study area to improve the understanding of small-scale land use-changes and their drivers.

5. Conclusion

This study links remote sensing and local perspectives to understand small-scale tropical forest change. One the one hand, our findings suggest that remote sensing data can be a valuable base for landscape planning at small scales. For detailed assessments of land use-changes and their drivers, local knowledge is however still crucial. On the other hand, our findings highlight the complexity and context-specificity of intended forest transitions. On the ground, we find that forest conservation struggles to keep pace with economic, policy and socio-economic drivers of agricultural expansion and economic development; and that local people do favor infrastructure and socio-economic development. Our study highlights that forest transitions are of an ambiguous, contentious and messy nature, and do not necessarily follow broad narratives about sustainable development enabled by reforestation.

Taken together, our study suggests that achieving the Laos national target of 70% forest cover requires integrating local perspectives and priorities into policy design. Participatory and adaptive approaches are essential, as acknowledging complex local socio-economic and environmental trade-offs allow policymakers to better align conservation efforts with on-the-ground realities. This research underscores the need for nuanced, context-sensitive forest policies that recognize the needs of local livelihoods as a prerequisite for reaching conservation goals, ultimately fostering a more sustainable, just, and effective approach to forest conservation in Laos and beyond.

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Data availability

Remote sensing data available. GEE apps, codes and assets: https://github.com/shijuanchen/shift_cult. Map products visualization: https://sites.google.com/view/shijuanchen/research/shift_cult. Data from focus groups and walking interviews available on request.

Declaration for use of AI

GPT-4o was used to improve the readability of the manuscript through phrasing suggestions and grammar corrections.

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