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Integrated Sustainable Land Management for Smallholder Agriculture in Laos

Introduction

"Prosperous farmers make for a prosperous nation, and when farmers are in trouble, the nation is in trouble" (Truman, 1956). This idea remains especially relevant in Laos, where agriculture supports the livelihoods and food security of many rural households. For smallholder farmers, land is one of their most important economic assets, yet its declining productivity can also make households increasingly vulnerable. Agrifood systems contribute roughly one-third of global greenhouse gas (GHG) emissions (FAO, 2024), placing agriculture at the center of climate mitigation. At the same time, feeding a growing population amid finite land and increasing environmental pressures requires that sustainability be placed at the core of food production. These challenges are especially important in Laos, where many people depend on smallholder agriculture (Bunch, 2012). Smallholders often operate with limited financial resources, restricted access to inputs and markets, and increasing climate-related risks that can threaten both income and food security. Land use is the strongest influence on vegetation cover in Laos, where agriculture, forestry, and mining have contributed to declining vegetation (Gao, 2024). This decline can threaten food security by reducing forest resources and increasing pressure on already limited agricultural land.

This paper recommends implementing an integrated sustainable land-management program for upland maize-growing communities in northern Laos, beginning in Huaphan Province and later adapting successful practices to other areas with similar farming and land-use pressures.

Country and Family Context

Laos is a landlocked country in Southeast Asia with a population of about 7.77 million. Around 61% of the population lives in rural areas (World Bank, 2026), where agriculture remains an important source of both food and income. Many households have limited financial resources, so

farming decisions are strongly influenced by immediate needs such as maintaining rice supplies, earning cash, and controlling production costs.

Rural diets also depend partly on surrounding natural resources. Forest foods such as bamboo shoots, wild vegetables, and fruits contribute to diet diversity and household nutrition (Jendresen and Rasmussen, 2022). This close connection between farming, household income, and natural resources makes land management especially important for rural communities in Laos.

Challenges and Impacts

One of the main challenges in northern Laos is the growing dependence on commercial maize: maize became attractive because it provided cash income, required less labor than upland rice, and had established buyers. However, repeated maize cultivation on steep slopes has contributed to declining soil quality, lower productivity, and greater financial risk when harvests fail or prices fall (Kallio et al., 2019).

These problems are intensified by Laos's limited arable land. Only about 5.3% of the country's land is classified as arable (TheGlobalEconomy.com, 2023), while agricultural expansion has increasingly reached upland and forested areas. Farming on steep slopes can accelerate erosion and reduce the long-term productivity of existing fields, while continued expansion places additional pressure on forests and biodiversity (Zeng, 2018; Struebig et al., 2025).

Together, these pressures create a cycle in which declining land productivity makes households more vulnerable to economic shocks and increases pressure to bring additional land into cultivation. Breaking this cycle requires addressing soil degradation, household economic risk, and pressure on forests as interconnected problems.

Recommended Solution: Integrated Sustainable Land Management in Northern Laos

Laos should implement an integrated sustainable land-management program for upland maize-growing smallholders, beginning in Huaphan Province. The program would combine better crop placement, conservation agriculture, diversification, market support, and appropriate technology to improve the productivity of existing farmland.

Use Existing Farmland More Efficiently

A promising pathway for sustainable land management in Laos is to use existing farmland more efficiently through strategic crop placement, diversification, and zonation. Because rural Laos is dominated by smallholder farmers, landholdings are heavily fragmented into small plots that are difficult and costly to consolidate. Instead of expanding into fragile highland areas, which accelerates soil erosion, land degradation, and long-term yield decline, smarter land use focuses

on cultivating the right crops in the right locations to maximize productivity while protecting soil health and forest ecosystems.

Global research demonstrates that optimizing crop placement can reduce irrigation demand by 12–21% without sacrificing overall food output (Davis et al., 2017). Furthermore, strategic crop switching can simultaneously lower water use, chemical inputs, and greenhouse gas emissions while enhancing financial returns. Regional studies, such as research from China, confirm that reallocating cropping structures on existing smallholdings increases agricultural output while reducing ecological pressure (Deng et al., 2024).

However, agricultural strategies developed elsewhere cannot simply be copied into Laos. Lao smallholders operate on steeper mountainous terrain with weaker rural infrastructure, distinct market dynamics, and smaller field sizes. Crop-planning decisions must therefore be adapted through local demonstration plots and participatory farmer planning rather than imposed through top-down policy transfers.

When tailored to the local context, efficient land use aligns with Laos's ongoing transition toward commercial cash cropping and permanent farming systems (Chen et al., 2023). In practice, this requires replacing continuous maize monoculture with a zonation strategy based on slope and soil capacity.

Lowland Valleys: Farmers can prioritize staple rice and rotate or intercrop with nitrogen-fixing legumes, such as soybeans, mungbeans, and groundnuts, to restore soil nutrients naturally and support household food security.

Moderate Slopes (10°–25°): Maize can be intercropped with leguminous cover crops such as Stylosanthes or pigeon pea, which shield topsoil from rain erosion while generating livestock forage and maintaining cash income.

Steep Slopes (>25°): Annual cultivation on suitable slopes should gradually transition toward locally appropriate perennial or agroforestry crops, such as cardamom, tea, fruit trees, or timber species, where reliable markets exist. Their permanent root systems can help stabilize hillsides, while reducing the need for annual tillage and providing farmers with higher-value harvests over time.

This system also balances commercial opportunities with basic food security. As observed in northern Laos, smallholders rely on maize for cash income but depend on upland rice as an indispensable safety net during market crashes or crop failures (Kallio et al., 2019). Protecting

dedicated staple-rice production alongside high-value cash crops ensures that commercialization does not jeopardize family survival.

Protect Soil Productivity Through Conservation Agriculture

Conservation Agriculture (CA) offers a system-based approach to restore degraded soils while stabilizing yields across upland Laos. CA is built around three core principles: minimal soil disturbance, continuous organic soil cover, and crop diversification. These approaches reduce soil disturbance and retain organic residues, helping maintain or increase food production while strengthening farm resilience to extreme weather.

Field studies in other regions have also demonstrated the potential benefits of these practices. A six-year study in the North China Plain found that replacing continuous cereal monocultures with diversified rotations, including cash crops like sweet potato and legumes like peanut and soybean, increased equivalent yields by up to 38%, reduced nitrous oxide emissions by 39%, and improved overall soil organic carbon by 8% (Yang et al., 2024). Supporting research confirms that no-till practices lower soil carbon emissions (Shakoor et al., 2024), while cover crops increase subsequent crop yields by an average of 9.7% compared to leaving fields fallow (Fan et al., 2021). In Laos, conservation agriculture has been evaluated across 21 villages, demonstrating that these practices are viable under Lao farming conditions, although adoption remains uneven (Lestrelin et al., 2012).

Among these practices, legume integration is already familiar in Lao farming systems, such as combining pigeon pea or cowpea with non-irrigated upland rice (Bunch, 2012). However, in northern maize-growing areas, limited markets for legumes may make perennial cash crops a more practical diversification option. Integrating crops such as coffee, banana, fruit trees, and fast-growing timber species into maize-based systems could provide additional income opportunities while improving land use (Quoc et al., 2025).

Support Sustainable Land Management with Smart Technology

Effective sustainable land management in Laos will increasingly depend on pairing proven conservation practices with targeted technological innovation. Technology should be practical for smallholder farmers and suited to local conditions, while also allowing communities to benefit from emerging tools that can improve efficiency over time. Carefully integrating appropriate technologies can help farmers use land and other resources more efficiently, reduce unnecessary input losses, and improve income from fragile upland areas.

Three technology tracks stand out. First, high-efficiency inputs such as nano-enabled fertilizers and pesticides can deliver active ingredients directly to plant roots, boosting nutrient uptake while reducing chemical runoff on steep hillsides. Improving nitrogen-use efficiency is particularly vital for maize and rice farmers in Laos, as it allows households to maintain yields while lowering their exposure to volatile global fertilizer prices and cutting agricultural nitrous oxide emissions. Because nano-enabled products are still emerging, their cost, effectiveness, and environmental safety should be tested under Lao soil and farming conditions before wider use.

Second, digital tools can support more precise land and crop management. Regional evidence suggests that platforms such as WhatsApp and Facebook may be more practical for smallholders than specialized agricultural apps. Research on farmers in Indonesia, Myanmar, and Vietnam found that many used local messaging groups to exchange agricultural advice, product information, and market prices (Ellis, 2020). Field evidence from China indicates that internet access is closely associated with lower fertilizer and pesticide expenses per hectare, partly because farmers can obtain agronomic information more quickly and improve decisions about timing and dosage (Guo et al., 2026). Agricultural drones could provide another useful tool for upland management. Shared drone services operated by cooperatives or local providers could be tested for crop monitoring and targeted spraying on steep or difficult-to-access fields, where more precise application could reduce hazardous chemical exposure and prevent over-application.

Third, advanced plant breeding supplies smallholders with crop varieties suited to local soil and climate constraints. Precision-designed crop varieties can sustain high yields under lower fertilizer regimes, tolerate seasonal droughts, and resist regional pests without heavy chemical use. This technology has already shown promising potential in Laos. In Attapeu Province, the International Water Management Institute and the Lao Farmer Network supported farmers in adopting a high-value red rice variety. Field trials from 2023 to 2025 reported yields of up to approximately five tons per hectare together with strong income potential (Chanthalath, 2025). Similar variety-testing and seed-distribution programs could identify maize, legumes, and other crops better suited to the soils, slopes, and climate conditions of northern Laos.

Projected Economic Benefits

Conservation-based land management has the potential to improve smallholder profitability. Evidence from southern Xayabury supports these benefits. In smallholder pilot trials comparing direct-seeding mulch-based cropping systems (DMC) with conventional ploughing (Table 1), one village saw production costs fall from $226 to $95 per hectare, while net income increased

from $288 to $429 per hectare and labor productivity rose from $5.73 to $7.67 per day. In another village, production costs declined from $201 to $90 per hectare, while net income increased from $234 to $423 per hectare and labor productivity more than doubled from $3.25 to $7.10 per day (Panyasiri & Tivet, n.d., p. 33).

Table 1. Economic Outcomes of Direct-Seeding Mulch-Based Cropping (DMC) Compared with Conventional Ploughing in Southern Xayabury

	Village 1	Village 2
Production Cost decrease	$226 → $95/ha	$201 → $90/ha
Net Income increase	$288 → $429/ha	$234 → $423/ha
Labor Productivity increase	$5.73 → $7.67/day	$3.25 → $7.10/day

Source: Panyasiri & Tivet (n.d., p. 33).

Diversified land use could provide additional financial benefits. A financial analysis from Laos found that an integrated Eucalyptus-rice system achieved an internal rate of return of 20.1% and a long-term land value of about $1,459 per hectare, while first-year rice production contributed approximately $186 per hectare in net value (Phimmavong et al., 2019). Although these exact returns cannot be assumed for Huaphan Province, they demonstrate that combining perennial crops with household food production can be financially viable under Lao conditions. Diversification could also provide alternative sources of income when maize prices or yields decline.

At a broader economic level, healthier soils can help maintain yields and reduce the need for intensive land preparation, while better soil cover can limit erosion and damage to local water systems, roads, and other infrastructure. Although difficult to quantify, these benefits help preserve the long-term value of upland farmland.

For smallholders, the broader economic benefit is greater profitability and financial resilience from land already in use. Lower production costs, healthier soils, and more diverse sources of farm income can make existing farmland more productive and economically secure. This gives households a stronger incentive to maintain and improve their land rather than expand cultivation onto increasingly fragile upland areas.

Barriers and Policy Recommendations

To support the integrated sustainable land-management program, the Lao government should establish an Upland Sustainable Land Management Policy Framework, beginning in Huaphan

Province. The framework would coordinate four major components: transition assistance, stronger market support, farmer training and extension, and land-use planning. Together, these measures would address the main financial, market, technical, and land-use barriers that could limit long-term adoption.

The first component, transition assistance, would address initial economic and risk barriers. The government should provide temporary transition assistance, potentially in collaboration with organizations such as the Lao Farmer Association. Conservation agriculture trials across Laos have faced uneven adoption largely due to upfront labor demands, land-access constraints, and limited institutional backing (Lestrelin et al., 2012). Providing smallholders with short-term access to quality planting materials, shared equipment, village demonstration plots, and targeted low-cost credit, with dedicated allocations for poorer and land-constrained households could buffer families against these financial risks while new practices take root. Where promising technologies remain too expensive for smallholders, temporary government subsidies or shared-service programs could also help lower initial costs and make adoption more realistic.

The second component would strengthen market access through farmer cooperatives. Maize expanded rapidly in northern Laos partly because commercial traders provided credit, seeds, and market outlets; however, reliance on a narrow buyer network exposed smallholders to price volatility and debt when harvests failed (Kallio et al., 2019). Farmer cooperatives could help aggregate harvests, lower transport costs, share market-price information, and connect farmers with multiple buyers for alternative crops.

The third component would expand technical support and farmer training. The government should expand agricultural extension services and provide more hands-on training for farmers. Existing organizations, such as the Lao Agriculture Cooperative Federation, could help coordinate these efforts. Development organizations and private companies could also help by providing technical advice and demonstrating specialized equipment. Research on agricultural firms in Laos found that learning, resource allocation, marketing, and organizational capabilities were associated with stronger innovation performance (Paovangsa et al., 2025). Farmer field schools and lead-farmer networks could provide a practical way to deliver this support at the village level, allowing farmers to learn through demonstrations and field-based testing before adopting new practices or technologies. Training could focus directly on land-management tasks such as residue management, no-till seeding, efficient input application, and the use of shared equipment. Although expanding these services would require public investment, stronger farmer knowledge could improve the long-term effectiveness of sustainable land-management practices.

The fourth component would strengthen land-use planning to prevent agricultural expansion into forests. Infrastructure development and commercial agriculture continue to place pressure on land and forests across Laos (Dong et al., 2024). The government should clearly identify which areas are suitable for farming and which should be protected, especially steep slopes, watersheds, and important forest areas. Satellite monitoring can help identify new clearing, while local communities should be involved in spatial land-use decisions.

Implementation Timeline and Evaluation

The program should follow a phased 10-year implementation strategy beginning in Huaphan Province (Table 2), where upland communities have already experienced the environmental and economic effects of commercial maize expansion. Xone District provides a useful starting context because maize expansion there has been associated with declining soil productivity, market instability, and pressure on forests surrounding the Nam Et-Phou Louey National Protected Area (Kallio et al., 2019).

Table 2. Phased Implementation and Evaluation Plan

Period	Main Focus	Key Actions*	Evaluation**
Years 1–2	Establish and introduce	Baseline assessment; land-use zoning; farmer training; demonstration fields; soil conservation; diversification; low-cost technologies	Baseline soil, income, rice security, yields, and land use
Years 3–5	Expand and adapt	Expand successful practices in Huaphan; strengthen markets; introduce proven technologies; adapt practices to local conditions	Reviews in Years 3 and 5; soil condition, costs, crop diversity, market access
Years 6–10	Broaden application	Refine practices in Huaphan; adapt successful approaches to other upland maize-growing area	Year 10 review; livelihood stability, rice security, soil health, forest protection

* ***Main responsibility:*** *MAF coordinates the program; Huaphan provincial authorities and DAFO lead local implementation with village authorities and farmer groups.*

** ***Key outcomes:*** *more stable farm livelihoods, household rice security, healthier upland soils, and less agricultural expansion into forests.*

During Years 1–2, the Ministry of Agriculture and Forestry, Huaphan provincial authorities, district Agriculture and Forestry Offices (DAFO), and participating villages should establish baseline conditions and begin implementation. The program should build on existing village land-use boundaries and zoning. Training and demonstration fields should focus on soil conservation on sloping maize fields, crop diversification, maintaining sufficient rice production, and introducing suitable perennial crops. Appropriate technologies should begin to be introduced during the second half of Years 1–2, after baseline conditions are established and farmers receive initial training. Low-cost and locally maintainable tools should be introduced first, while more expensive technologies should only be expanded during Years 3–5 if they prove useful, affordable, and practical under upland Lao farming conditions.

During Years 3–5, practices should expand within participating villages and into other maize-growing communities in Huaphan. This stage should also strengthen market connections for diversified crops. Because maize development in northern Laos differs even between nearby districts depending on road access, traders, markets, and land-use history, expansion should not follow a single model for every village (Kallio et al., 2019). During Years 6–10, approaches that perform well in Huaphan could be adapted for other upland maize-growing districts.

Evaluation should concentrate on outcomes that matter to upland Lao households. Economic monitoring should measure whether households are becoming less dependent on maize income and whether they have reliable markets for additional crops. Food-security monitoring should track rice production and the number of months households can meet their staple-food needs, since rice continued to function as the main food source and safety net (Kallio et al., 2019). Agricultural monitoring should track maize yields, input costs, crop diversity, and soil condition on sloping fields. Soil testing could be conducted at baseline and again in Years 3, 5, and 10.

Environmental monitoring should focus on agricultural expansion into village forests and protected-area buffer zones. This is relevant in Huaphan because commercial maize cultivation has encroached into areas surrounding the Nam Et-Phou Louey National Protected Area (Kallio et al., 2019). Existing Lao land-use records can be combined with satellite data and the Lao PDR Geographic Information Platform to compare agricultural and forest areas over time (Dong et al., 2024).

Responsibility should also follow existing Lao institutions. The Ministry of Agriculture and Forestry would provide overall coordination, while Huaphan provincial agricultural and forestry authorities and district DAFO offices would manage implementation with village authorities and farmer groups. This type of collaboration is already used in agricultural and forestry research in

Laos, involving the Ministry of Agriculture and Forestry, National University of Laos, and district Agriculture and Forestry Offices (Kallio et al., 2019). Village representatives should collect simple information on production, food availability, participation, and farmer concerns, while technical soil and land-use assessments should be handled by government specialists, universities, or development partners.

A major review in Years 3, 5, and 10 should determine whether the program is achieving four central outcomes: more stable farm livelihoods, continued household rice security, healthier and more productive upland soils, and less agricultural expansion into forests. If progress is weak in a particular village, the program should adjust crop choices, market support, or land-management practices rather than applying the same approach everywhere.

Conclusion

Laos's future food security depends on empowering its smallholder farmers. An integrated sustainable land-management approach can help farmers use existing land more productively, diversify crops, protect soil, and reduce pressure on surrounding forests while maintaining reliable livelihoods.

Beginning in Huaphan Province and expanding to similar upland communities, this approach could strengthen farmers' resilience to crop failures, price changes, and climate pressures. Beyond Laos, smallholder farmers in many countries face the same challenges of limited land, soil degradation, and unstable markets. Laos therefore offers a useful example of how integrated land management can support food security, strengthen rural livelihoods, and build more resilient agricultural systems in other smallholder farming regions.

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