

De-intensification and intensification effects of migration on farming systems: A systematic review from Nepal

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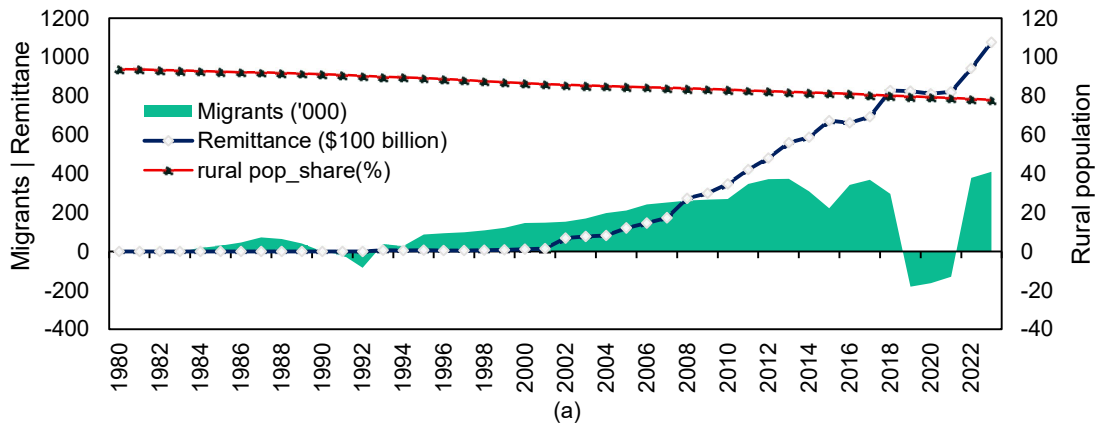
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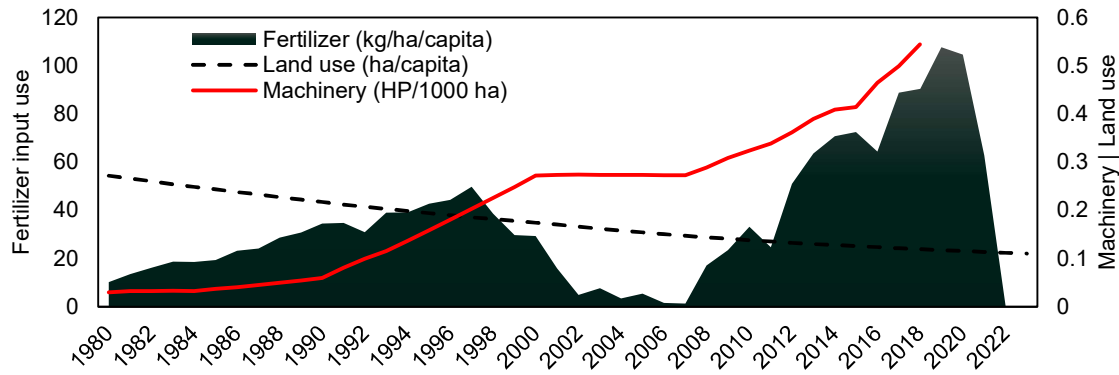
Introduction

The transformation of land use and food systems began as soon as hominins started actively appropriating and managing ecosystems shaped over millions of years (Lorenzen et al., 2020; Novotny et al., 2021; Jurjonas et al., 2023). While earlier transformations were largely driven by ecological processes, subsistence needs, and climatic variability, the drivers have shifted over time to include technological innovation, demographic change, institutional arrangements, and human migration, reshaping land use patterns across local, regional, and global scales (López et al., 2006; De Brauw and Rozelle, 2008; Li et al., 2013; Su et al., 2014; Antoni et al., 2019; Lorenzen et al., 2020). In the last few decades, outmigration has shifted labor dynamics, creating a human resource shortage (Holland, 1976; Cohen, 2003). Such phenomena have been globally observed across time and considered to pose long-term challenges among rural commons in conserving and managing natural resources, such as land, water and others, that holds direct/indirect feedbacks on the long-term functionalities of life-support systems, including agriculture (Antoni et al., 2019; Lorenzen et al., 2020; Novotny et al., 2021; Jurjonas et al., 2023).

Instead of benefiting from demographic dividend, most of the economically active population migrate both internationally and domestically with significant impacts on farming systems (Bardhan, 1993; Rozelle et al., 1999; Gartaula et al., 2012; Jaquet et al., 2015). As a result, remittance emerges as a critical economic pillar, for instance, contributing nearly 33.1 percent to Nepal’s gross domestic product in 2024 (The World Bank, 2025a). These movements through various mechanisms are considered to bring far-reaching outcomes, driving rural-urban transitions and reshaping farming systems (Bardhan, 1993; Rozelle et al., 1999; Gartaula et al., 2012; Jaquet et al., 2015). Past studies have theoretically and/or empirically explored interconnected processes of migration, remittance, and development, revealing complex and context-dependent relationships among them (De Haas, 2010; Lihua et al., 2013; De Haas et al., 2019; Kapri and Ghimire, 2020). A group of studies finds migration’s roles in poverty reduction, improved education, and consumption (Cantore and Cali, 2015; Borderon et al., 2019), while others present its negative impacts on inequality, agriculture, land use, and sustainability (Jaquet et al., 2015; Gavonel et al., 2021; Crawley et al., 2022). These conflicting findings underscore the influences of social, economic, and production conditions, highlighting why context-specific analyses are necessary to understand migration, remittance, and farming systems, as argued by De Haas (2010), Li et al. (2013), and Cantore & Cali (2015).

Nepal, being second to Tajikistan in reliance on remittance for national economy (The World Bank, 2025b), is an archetypical case to draw lessons on migration and farming system transformation in low- and middle-income countries of the global south. Over the past four decades, Nepal has experienced a remarkable socioeconomic transformation due to increasing net out-migration and the respective remittance inflow (Figure 1). Despite being a historical phenomenon since early settlers, recent records show that net outmigration has grown steadily since the 1980s, with a notable surge in the early 2000s until 2018 and resurged from 2021. There were notable declines in outmigration between 1991 and 1992 and between 2019 and 2021, following democracy establishment and COVID-19, respectively. While Nepal is challenged by increasing labor outflow, remittances have exponentially increased, thereby offsetting the effects. Limited literature captures remittance-induced rural-urban migration, but the rural-urban population share, as in Figure 1, shows a steady decline over five decades. Along with these demographic shifts, Nepal has experienced rapid land use and farming system transformations (Basu, 2000; Gartaula et al., 2010; Gartaula et al., 2017). For instance, whilst land available per capita declined from 0.217 to 0.11 ha/person between 1990 and 2023, fertilizer use increased. The increase in fertilizer use was supported by subsidies, which are being withdrawn, and farm families increasingly rely on remittances (Shrestha, 2010; Upadhyay et al., 2019; FAO, 2025). Similarly, machinery use increased during the 1990s, stabilized between 2000 and 2006 during the Maoist conflict period, and the recent exponential increase is associated with increased remittance inflow. The accelerated uptake of fertilizers and machinery indicates a transition toward capital-intensive farming practices.





(b)
 Figure 1: (a) Number of migrants (in thousands), remittance inflow (USD Hundred Billion), and percentage share of rural population for 1980-2022; (b) Per capita land use (ha/capita) and fertilizer use (kg/ha/capita), and average machinery use (HP/1000 ha) for 1980-2022. (Sources: World Bank, 2025; World in Data, 2025)

These input-use patterns entail that the farming systems have undergone significant transitions due to outmigration and labor shortage, while farming families adapt by leveraging remittance inflows for technological substitution. Despite the scale of migration and its transformative implications for farming systems, existing literature has constructed fragmented and incoherent pathways through which migration induces farming systems' transformation. As a result, policies and programs are designed with one-dimensional perspectives and plans. For instance, whilst MoLESS (2022) recognizes gaps and challenges in both policy and practice and devises remedial actions, it is not well aligned with international (Lee et al., 2016) and national policies (MoYS, 2015), programs, and directives that provide detailed information on migration trends, governance, health, and safety. The policy mismatch overlooks the multifaceted effects of outmigration on farming systems. Contextually, this systematic review aims to examine the existing body of knowledge and develop a first account of how migration simultaneously induces extensive and intensive land use and how farming systems transform in Nepal. By drawing on interdisciplinary perspectives, we identify pathways and associated trade-offs of migration-driven changes. Although we focused our study on Nepal, the migration, labor shortage, remittance, and farming system trends are observed across the low- and middle-income countries; hence, these results can be applied to other regions (Sivakumar and Rajan, 2022).

Methods

Conceptual frameworks

With a disciplinary bias, past studies have framed migration and farm resources using structural migration theories (e.g., push-pull), focusing on understanding how people movement impacted the farm resource component structure (Rozelle et al., 1999; Li et al., 2013; Kapri and Ghimire, 2020). An increasing volume of literature posits that social transformation and economic development increasingly shape migration in complex and counterintuitive ways, revealing the inadequacy of conventional migration theories (De Haas, 2021). Therefore, the theoretical question for this study is not "Why do people leave agriculture?" which would generate overly generic unidirectional relationships, but rather "How do patterns and experiences of farming systems shape or get shaped by social restructuring?" (De Haas, 2021). To explore the complex relationship between outmigration and farming systems, we adopt the DPSIR (Driver-Pressure-State-Impact-Response) framework (Kelble et al., 2013). Originally developed in ecological studies, the DPSIR framework allows structured forward- and backward linkages, which are key in analyzing migration's interaction with land use (Kelble et al., 2013; Pinto et al., 2013; Hou et al., 2014; Dzoga et al., 2020).

Within the broader DPSIR framework, theories on migration, labor, and human behavior provide fundamental explanations of factors that trigger migration and how migrants respond (De Haas, 2021; Hoffmann et al., 2019; Lee, 1966). Although we first use push-pull to explore the migration triggers, we draw upon the New Economics of Labor Migration (NELM) to conceptualize a HH-level strategy for mitigating local market failures by reallocating labor and channeling remittances, thereby stabilizing income and facilitating investment (Stark and Bloom, 1985; Rozelle et al., 1999; De Brauw and Rozelle, 2008; Sindi and Kirimi, 2006). We further use Ajzen's Theory of Planned Behavior (TPB) (Ajzen, 1991) to explore how a household's agricultural decisions, including adopting innovations or modifying land-use strategies, are shaped by attitudes, subjective norms, and perceived behavioral control. We then build on the Prospect Theory (Kahneman and Tversky, 2013) to examine pathways through which households' (hereafter, HH) members pose heterogeneity in risk preferences, the variations in their willingness to invest in capital-intensive farming, or behavioral shifts to low-risk, non-agricultural activities.

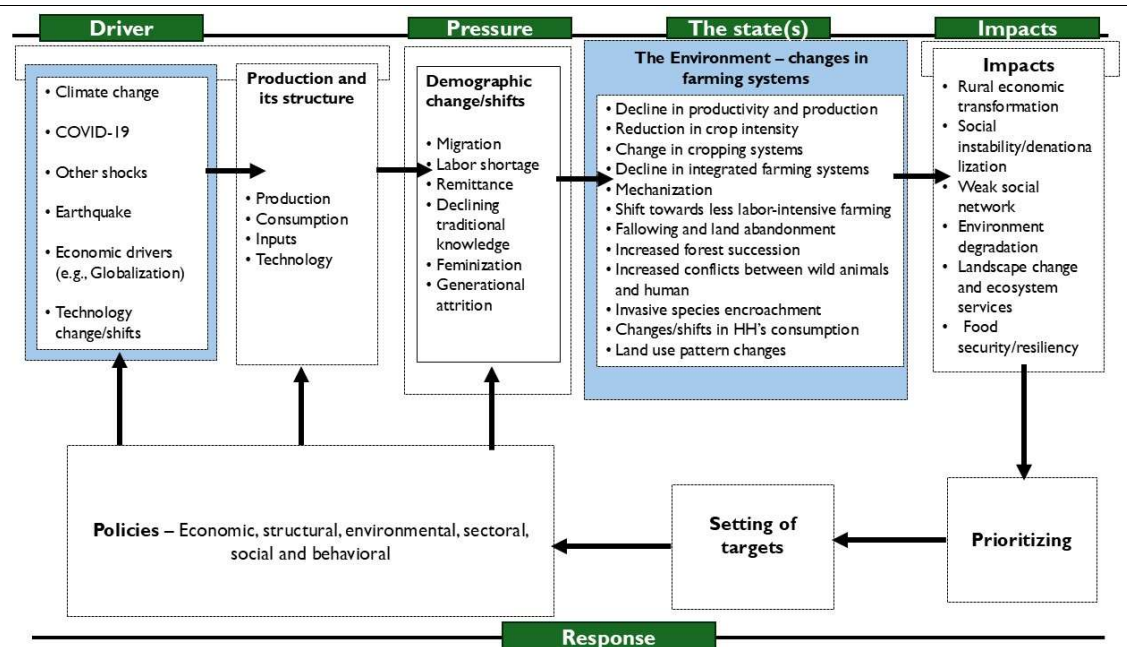


Figure 2: Adapted DPSIR framing migration and farming system transformation.

This aligns with classical models of structural transformation, such as the Lewis Dual Sector Model, which are used to explain the reallocation of labor from subsistence agriculture to more remunerative off-farm sectors, thereby diminishing reliance on traditional farming (Bhattarai and Kulkarni, 2011; Moloji et al., 2020). To complement this, the Structural Transformation Theory (Timmer, 2009) elucidates a bifurcation within agrarian societies—where a subset of HHHs’ transitions toward commercialization and technological intensification, while others experience increasing marginalization due to unaddressed labor constraints (Teixeira and Queirós, 2016; De Haas, 2021). These frameworks collectively present how migration acts as both a driver of agricultural intensification, through investment and capital substitution, and of extensification, through land abandonment and labor contraction.

Review process

This study employed a systematic review approach following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency, rigor, and reproducibility in the review process (Moher et al., 2009; Page et al., 2021). We structured the methodology in four phases (Figure 3).

Literature search strategy

The literature search was conducted between August 2024 and November 2024. A pilot search was initiated to identify relevant keywords within thematic areas—outmigration impacts, gender effects, labor shortages, remittance, and agricultural outcomes—that were later used to develop a matrix of search terms. Search strings were tailored to capture various facets of outmigration and agriculture in Nepal as framed by migration, labor, structural transformation, and behavioral theories within the broader DPSIR framework. The key thematic search terms included “migration,” “mobility,” “depopulation,” “settlement,” “agriculture,” “livestock,” “farming,” “intercropping,” and “sustainable farming.” Boolean operators (AND, OR, NOT), truncation symbols (*), and wildcards (?) were used as appropriate. For each theme, structural and functional indicators were considered, including “labor,” “youth,” “migrant,” “worker,” “agriculture,” “capital,” “remittance,” “urbanization,” “rural,” “farming systems,” “crop,” “livestock,” “forest,” “land use,” “water,” “irrigation,” “inputs,” “market,” “production,” “consumption,” “food,” “expenditure,” “budget,” “income,” “rural development.”

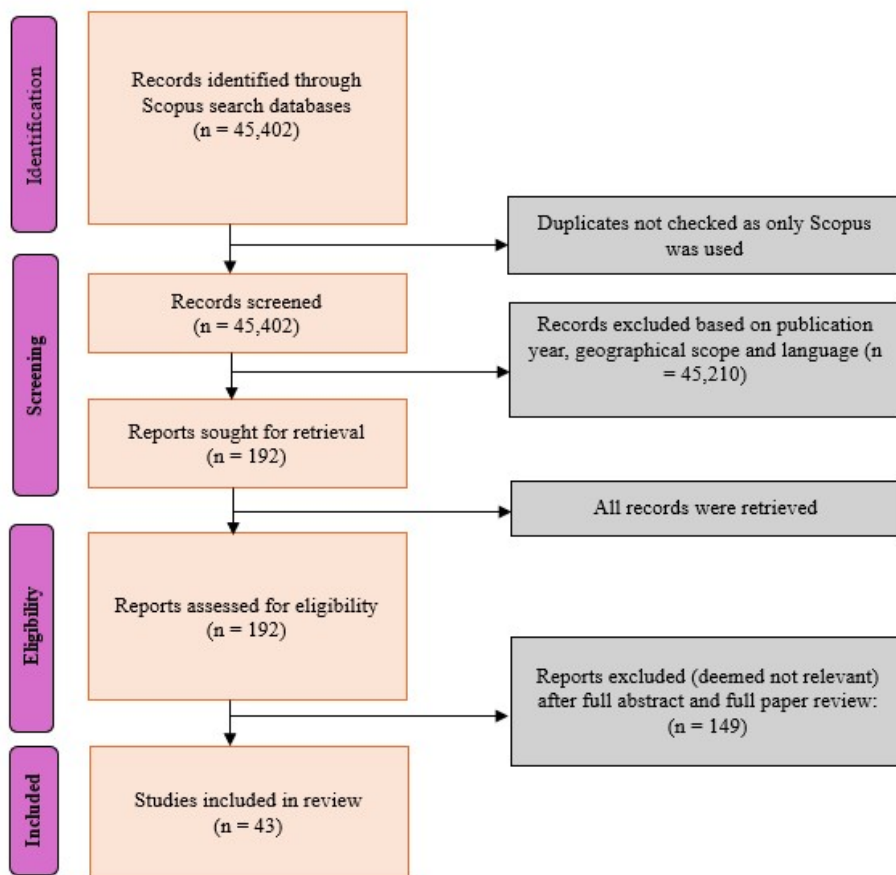


Figure 3: Flow diagram showing the steps involved in the systematic review.

Identification of databases and screening

The literature search was done using Scopus. The search results were managed using JabRef and Zotero reference management. The early search stages yielded 45,402 records from SCOPUS, as shown in Figure 3. Of these records, 45,210 studies were excluded as they were screened and marked as ineligible following automated filters, based on the unrelated themes (i.e., other than migration, agriculture, and farming systems), language (i.e., English), geographical scope (i.e., Nepal), and publication year (i.e., between 2010 and 2024). After screening, only 192 articles are sought for final inclusion.

Eligibility, exclusion, and inclusion method

The 192 articles were then exported and uploaded for authors' independent assessment-based title and abstract reading. Rigorous exclusion and inclusion criteria were adopted. Initial screening of titles and abstracts was conducted in Rayyan¹, with a double-review process to maximize inclusivity. Data from each selected study is extracted and categorized into thematic areas. Since rural HHs, specifically farmers, are primarily affected by outmigration, the study generally considered farmers as a population. Any form of outmigration, including labor migration to urban areas or abroad, whether they are permanent, temporary, or seasonal, are considered in the study. As the focus of the study is mainly to understand how outmigration has been impacting crop-livestock interactions, including the challenges associated with labor shortages, reduced livestock productivity, and emerging opportunities, we provided relatively higher weightage to these outcome variables. Two reviewers independently assessed the relevance and resolved discrepancies through consensus. Of the total 192 articles, the reviewers removed 149 articles (including both "excluded" and "maybe") based on the following reasons: wrong population, wrong outcomes and different geographical scope. Finally, 43 articles fulfilled the criteria and were included for the detailed review.

¹ <https://www.rayyan.ai/>

Data extraction

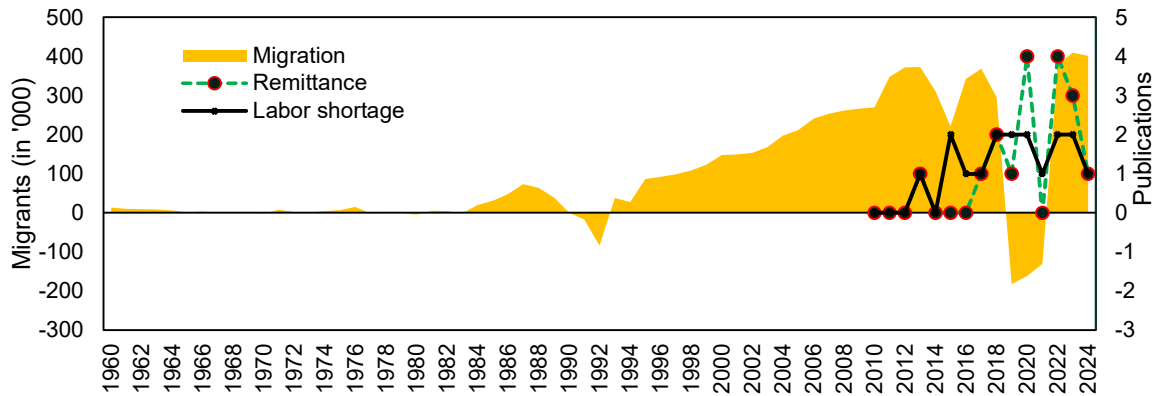
The results in this study were gathered through summative qualitative content analysis. We grouped the effects of the various variables based on the DPSIR framework to establish a logical flow from outmigration, remittance, and implications on farming systems. We initially started our review with five main groups: (i) structural and institutional variables, (ii) asset- and wealth-related variables, (iii) cognitive and non-cognitive variables, including people's consumption and production behaviors, (iv) sociodemographic variables, and (v) interplays among them. However, these themes we finally changed to eight themes that show how migration as a simultaneous driver of extensification (e.g., labor loss, abandonment) and intensification (e.g., remittance-led mechanization) brings changes and/or shifts to Nepal's farming systems' transformation, as shown in Table 1. Although the reviewed papers generally take land abandonment and fallowing as equivalent to each other in the context of Nepal (Ojha, 2017; Subedi et al., 2022), they have been conceptualized elsewhere as follow: (i) Perpiña Castillo et al., (2018) referred abandonment to the land that was formerly used to produce crops or pasture, but is no longer used for farming because of exogenous factors; and (ii) Fallowing is generally defined as land which is intentionally left uncultivated for a period to improve soil health and save soil moisture, as explained by Yang et al., (2019) and Zuo et al., (2020).

Results and Discussion

Trends, sources and geographical distribution of literature

Figure 4 depicts the 2010 to 2024 publication trends of studies on drivers and effects of migration on agriculture across Nepal. Although our review was capped from the year 2010, within this recent decade, we observe that the effects of migration on farming systems have received scholarly interest. First studies focused on labor shortages, but there was increased interest toward the remittance-agriculture nexus from 2020 onwards. These trends in labor shortage and remittance demonstrate the evolving concerns and interests on migration's challenges and its emerging opportunities, respectively.

The reviewed articles are published in a wide range of journals due to the interdisciplinary nature of the studied theme. The most common journals are Sustainability (5 articles), Technology in Society (2 articles), Trees, Forests and People (2 articles), Land Use Policy (2 articles), and World Development (2 articles). Among 43 articles, the study area of 30 articles was Mid-Hills, while 11 studies were carried out either in the Terai or inner Terai region. The geographic distribution of published articles across districts shows that most studies are from Palpa, Gorkha, and Chitwan districts, each with 3 articles, followed by Tanahun, Kaski, Dhading, Nuwakota, Ramechhap, and Kavre districts. These figures collectively reflect increasing migration-related issues (both challenges and opportunities) in the specified eco-belts.



(a)

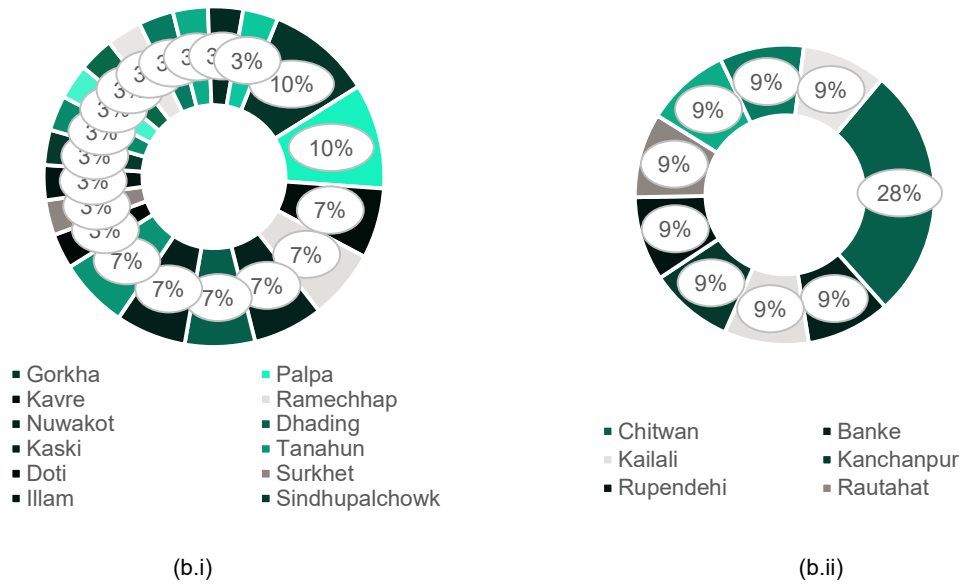


Figure 4: Spatial-temporal publication trends on remittance and labor shortage (a) against 2010-2024 historical migration and (b.i) distribution across districts in the Mid-hills or Mountain or (b.ii) Terai or Inner Terai.

Major farming system transformation pathways

From the existing volume of literature, we identified labor shortage and remittances as two proximate drivers of structural and functional transitions in farming systems (see Appendix 1). Within the DPSIR framework, labor and remittances drive the transformations through eight interlinked pathways: labor dynamics, land use, technology and machinery adoption, production, environment, feminization and gender equity, social inequality, and resilience. Through these mechanisms, migration has dual effects: it can either lead to farming system extensification (e.g., labor loss, abandonment) or intensification (e.g., remittance-led mechanization), as shown in Table 1. Half of the literature reported natural and human-induced shocks as sole or multiple drivers of migration decisions, including outmigration from rural to urban areas. Of these, a quarter cover climate-induced droughts and snowfall, earthquakes, civil conflict, and conflict with wildlife, which push HHs to take migration decisions (Prasain, 2018; Nepal et al., 2021; Gautam et al., 2020). Some studies established that migration decisions were influenced by other pull factors, such as industrialization, urbanization, and aspiration for better opportunities (Mukherji et al., 2018; Rijal et al., 2020; Bhandari et al., 2022). In contrast, significant literature reported that restrictions during the global pandemic, COVID-19, reversed migration decisions and pulled people towards rural farming activities (Bista et al., 2017; Rasul et al., 2021; Maraseni et al., 2022; Khatri et al., 2023). Studies focusing on post-migration underscored remittance as key social fabric connecting migrants with those left behind.

Labor dynamics, feminization, and land use change

Of the total 43 articles, a total of 32 articles highlight migration's multifaceted effects on labor shortage, influencing its markets, inflating wage rates, altering cropping patterns, and accelerating land-use changes, as presented in Figure 5. Literature shows that labor shortages push the rural wage rates up (Paudel et al., 2019; Aryal et al., 2021), improving agricultural workers' welfare but substantially reducing labor-intensive farm enterprises' profitability and productivity (Rana et al., 2018; Chaudhary et al., 2020; Bhandari et al., 2022).

Some literature explores and discusses linkages between migration and feminization (Barrueto et al., 2018; Rana et al., 2018), indicating two major pathways and an interplay between them through which migration influences farming systems. First, when men migrate, the left-behind workload associated with women increases as they assume tasks and responsibilities that are otherwise HH heads' (i.e., men) duties. These tasks, such as land preparation and plowing, irrigation and manuring, seed and fertilizer acquisition, labor hiring, pest management, harvesting and post-harvest operations, marketing, and so on, demand significant efforts and physical strength and are generally time-sensitive but vary across eco-belts and farming systems (Karki Nepal et al., 2023; Khatri et al., 2023; Smith et al., 2024). For instance, work burdens of women are found to increase among mid-hills HHs cultivating labor-intensive crops, such as rice, along with livestock integration, which often needs additional efforts and time due to difficult terrains and contours (Atreya et al., 2018; Paudel et al., 2019, 2020). In response, HHs are

found to make several adjustments in the farming systems, such as switching to non-labor-intensive crops, mechanization, and reducing cropping areas and livestock. Second, migration is reported to empower women by enhancing their access to assets, wealth (e.g., income and remittance), and intra- and inter-household decision-making (Doss et al., 2022). Findings from Leder et al. (2024) show that due to women’s increased empowerment and decision-making, irrigation systems did not weaken as it was anticipated when men migrated, implying that gender and social dynamics mediate and underscore migration’s effects on the farming systems. Local institutions are found to respond to migration’s challenges by adjusting institutional rules and arrangements to avoid institutions’ potential deteriorations in terms of significance, relevance, and sustainability. For example, Meinen-Dick et al. (2022) examine Water Users’ Associations (WUAs) across Nepal and argue that women-friendly adjustments in institutional rules and arrangements encourage them to reduce land abandonment through their participation in labor and cash contributions. Women are likely to continue their usual businesses by offsetting the men’s migration effects without major farming systems adjustments following this pathway (Sjöstrand, 2023; Leder et al., 2024).

Nonetheless, these changes are found not to be sufficient to influence women’s engagements and decision-making, plausibly because of relatively higher work burdens compared to empowerment from migration. Atreya & Gartaula (2022) show that women-headed HHs on average realize 5 percent less grain yield compared with HHs without men, which is associated with increased work burdens as they provide their livestock care and community engagement by 5.8 and 5.7 percent, respectively. When work burdens and women’s decision-making interact, HHs are increasingly found to migrate domestically (Ojha et al., 2017; Maharjan et al., 2021) when they see farming to be challenging compared to investing resources in real estate, children’s education, and off-farm opportunities in urban areas (Rijal et al., 2020; Wang et al., 2020). In contrast, Barreto et al. (2018) argue that the introduction of high-value nut crops, such as macadamia and walnut, can be taken as an innovation in farming systems if women’s capacities are enhanced. Thus, the ultimate direction and magnitude of migration’s effects on the farming systems’ intensification or extensification through feminization remain contingent on the contextual factors, such as women’s knowledge and priorities on agri-enterprises and abilities, and social norms, that determine their choices and actions in response to migration.

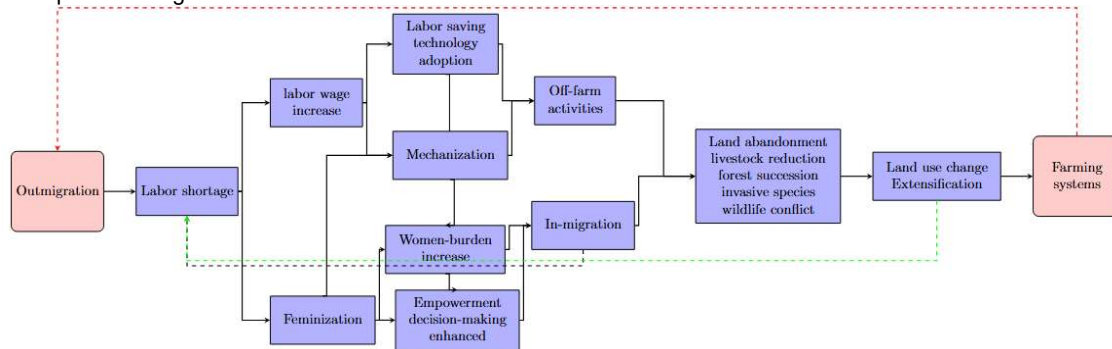


Figure 5: Pathways (blue) through which outmigration-induced labor shortages influence farming systems in Nepal.

A review indicates a total of 0.97 million ha of agricultural land was abandoned, representing 23.9 percent of the total cultivated land (Chaudhary et al., 2020). Most of the reviewed studies consider migration as one of the drivers for increasing rate of agricultural land abandonment (Pradhan & Sharma, 2017; Rai et al., 2019; Paudel et al., 2019; Wang et al., 2020; Chidi et al., 2021; Smith et al., 2024; Poudel et al., 2024). By correlating with land use changes from 1986 to 2010, Pradhan & Sharma (2017) found that migration contributed to agricultural land abandonment, and Bhandari et al. (2022), using the 2000–2019 data, found a positive correlation between migration and agricultural land use changes. An empirical intra-household study established that the link to migration is direct and measurable: farming households with migrants were 50 percent more likely to abandon agricultural land compared to those without migrants (Karki Nepal et al., 2023a). Abandonment is not uniform across the country; distinct geographical patterns across eco-belts exist. For instance, Rai et al. (2019), through a household cross-sectional study, found higher abandonment rates in the mountains and hills of 48 percent and 15 percent, respectively. In contrast, in highly productive Terai regions, agricultural land abandonment was at 4 percent. These trends correlate with productivity gradients as corroborated by Paudel et al., (2020). In addition, endogenous HH attributes, access to agronomic solutions, and market characteristics play roles in land use dynamics (Khanal, 2018; Paudel et al., 2020). Pradhan and Sharma (2017), Raju Rai et al. (2019), Bhandari et al. (2022), and Smith et al. (2024) report that abandonment is primarily driven by (i) migration, distance to market, and aging HH heads in Mountain; (ii) distance to farmlands (both khet and bari), HH’s head occupation, lack of training, and poor irrigation in Hill; and (iii) HH head and limited irrigation access in Terai. Over time, there is increasing empirical evidence on the positive association between migration and forest regeneration, especially in rural mountains and hills, resulting in forest succession (Pradhan & Sharma, 2017; Rai et al., 2019; Bhandari, 2022; Smith et al., 2024).

Table 1: Migration’s effects through labor shortage and remittance on farming systems across themes and citing studies.

Theme	Labor shortage effects	Citations	Remittance effects	Citations
Labor dynamics	<ul style="list-style-type: none"> • Decrease in labor supply • Differentiated effects across eco-belts (Mountain and Hills – high, Terai – low) • Feminization • Increased labor wage rates 	Paudel et al., 2019; Gautam et al., 2020; Chaudhary et al, 020; Bhandari, 2022; Meinzen, 2022; Karki Nepal et al., 2023; Khatri et al., 2023; Smith et al., 2024)	<ul style="list-style-type: none"> • Increased wage rates • Hired labor substitution • Reduced farm motivation • Crop choice changes/shifts • Mechanization 	Paudel et al., (2019); Karki Nepal et al., (2023)
Land use change	<ul style="list-style-type: none"> • Increasing land abandonment and uses • Differential effects across eco-belts (e.g. Mountain and hills – 48 percent vs. Terai 4 percent) 	Pradhan & Sharma, (2017); Rai et al., (2019); Paudel et al., (2019); Wang et al., (2020); Chaudhary et al., (2020); Chidi et al., (2021); Smith et al., (2024); Bhandari et al., (2022); Poudel et al. et al	<ul style="list-style-type: none"> • Differential effects on Intensification (Terai) • Abandonment 	(Rana et al., 2018; Atreya, 2018; Brown, 2020; Maharjan et al., 2021; Karki Nepal et al., 2023a)
Technology adoption	<ul style="list-style-type: none"> • Labor-saving technology adoption increases. • Spur mechanization • Increase off-farm activities promote technology adoption but constraints with elevation 	Paudel et al., (2019); Aryal et al., (2021); Meinzen-Dick et al., (2022)	<ul style="list-style-type: none"> • Climate-resilient tech adoption 	Paudel et al., (2019); Aryal et al., (2021); Maharjan et al., (2021); Meinzen-Dickick (20
Production/yield	<ul style="list-style-type: none"> • Production capacity diminished as HHs chose off-farm livelihoods away from agriculture. • Stable crop decline (paddy, maize, and millet by 21, 5 and 26 percent, respectively) 	Brown (2020); Bhandari et al., (2022); Tuladhar et al., (2014); Shahi et al., (2022)	<ul style="list-style-type: none"> • Marginal increase maize yield (20 percent increase in remittance, 1 percent increase in yield) • High-value crop diversification • Productivity increase • Increased use of fertilizers/irrigation 	Atreya et al., (2018); Paudel et al., (2019); Maharjan et al., (2021); Bista et al., (2022); Khatri et al., (2023); Karki Nepal et al. (2023); Kapri and Ghimire, (2020)
Environment /Ecology	<ul style="list-style-type: none"> • Forest succession • Terrace degeneration (paddy fields are increasingly covered by weeds and invasive species) • Human-wildlife conflicts • Invasive species 	Baral et al., (2021); Chaudhary et al., (2020); Shahi et al., (2022)	<ul style="list-style-type: none"> • Soil/water degradation • Declined forest dependency. • Reduced fodder collection and other products 	Atreya et al., (2018); Shahi et al., (2022)
Gender equity	<ul style="list-style-type: none"> • Increased work-burden • Empowers decision-making 	Barrueto et al., (2018a), Rana et al., (2018) Paudel et al., (2019), Doss et al., (2022) Meinzen-Dick et al., (2022)	<ul style="list-style-type: none"> • Mechanization with limited technology access 	Brown (2020); Aryal et al., (2021)
Social Inequality	<ul style="list-style-type: none"> • Smallholder marginalization • Enhance adaptive cap 		<ul style="list-style-type: none"> • Geographical and economical class biases 	Aryal et al., (2021); Meinzen-Dick et al., (2022)
Resilience Institutional aspects	<ul style="list-style-type: none"> • Labor shortage has drained brains, affecting capital formation. • Enhance adaptive capacity • Risk-averse (extensification) 	Rai et al., (2019); Bhandari et al., (2022); Meinzen-Dick et al., (2022); Shahi et al., (2022); Karki Nepal et al., (2023); Leder et al., (2024)	<ul style="list-style-type: none"> • Risk-taking (intensification) 	Brown (2020); Bista et al., (2022)

Source: Authors' extraction, 2025.

Agricultural land abandonment directly affects HHs' crop production and income. Bhandari et al. (2022) examined the influences of migration and remittance on land use change and crop production among rural HHs in mid-hills between 2009 and 2019, finding that labor shortage-led abandonment negatively contributed to 21, 5, and 26 percent declines in paddy, maize, and millet production, respectively. These reductions in production imply that rural HHs are on average losing 114 kilograms of crops annually, equivalent to USD 79 (\approx NPR 10,270). By analyzing HHs' livelihoods between 2004 and 2019, Shahi et al. (2022) showed that HHs with forest-agriculture livelihoods reduced from 60 to 19 percent, demonstrating further extensification of farming systems. The extensification of farming systems and subsequent reliance on food imports have been widely experienced by rural HHs, perceiving this as a potential threat to food sovereignty (Brown, 2020), which is also confirmed by Devkota et al. (2023). With the increased domestic migration and shifting livelihoods from agriculture-forestry to others, further land abandonment is inevitable.

Forest succession, post migration, influences farming systems through two pathways: it promotes human-wildlife conflicts, increasing the crops and livestock damage (Baral et al., 2021), and, preceded by land abandonment, it facilitates rapid spread of invasive plant species. Banmara (*Ageratina Adenophora*), Nilogandhe (*Ageratum houstonianum*) and Banmara (*Lantana camera*) have been recorded in the thicket of farming systems (Baral et al., 2021; Chaudhary et al., 2020; Shahi et al., 2022). These changes and shifts are considered counterproductive to the sustainable farming systems, as invasive species reduce soil productivity, increase management costs and losses, decrease biodiversity, and contribute to long-term land degradation and disruption in ecosystem processes (Yadav et al., 2024).

In addition to the transformations by the left-behind migrant family members, the pandemic and shocks have reportedly offered reversive forces, creating opportunities as returnee migrants engage in agriculture (Khatri, 2023). The process, though temporary as we observed between 2019 and 2022 (Figure 1), increased labor availability, resulting in resuming subsistence farming on previously abandoned agricultural land. Except for these years, the long-term trend of rural outmigration has continued, exacerbating structural labor deficits in Nepal's agrarian economy (Bista et al., 2017; Khatri et al., 2023). In summary, migration through labor shortage has generally contributed to farming systems through different pathways. First, it has feminized agriculture by increasing work burdens and empowerment while also inducing HHs to adopt labor-saving technologies and mechanizations to minimize the negative influences of labor shortages on farming systems. Depending upon the context, either of these pathways is found to promote HHs to choose off-farm activities, pushing them for domestic migration, resulting in land abandonment, forest succession, and land use changes and eventually extensification of farming systems. Remittance investment in agricultural and supporting enterprises

Empirical evidence reported and discussed in subsection 3.2.1 established that outmigration led to severe labor shortages in crop and livestock production, inducing farming systems extensification. However, there is an increasing empirical counter pathway: migrant remittances play a critical role for migrating HH as a financial lifeline and safety net, thereby supporting them to overcome liquidity constraints (Prasain, 2018; Nepal et al., 2021; Shahi et al., 2022; Matthys et al., 2024). For instance, Nepal et al. (2021) reported that about 64 percent of HHs in the mid-hill Sunapati rural municipality in the Ramechhap district consider seasonal migration as a coping mechanism in response to resource scarcity and market and climate shocks, such as prolonged droughts. Some studies have reported that the increasing reliance on remittances introduces new vulnerabilities in the migrating HHs and societies, especially when they are exposed to shocks, such as earthquakes and COVID-19 (Maraseni et al., 2022). Other studies show that HHs migrate to enhance their adaptability and resilience: they use remittances for consumptive uses (e.g., buying foods from the market) but also largely invest in education, health, and agriculture. Since this review is mainly focused on exploring and assessing how migration-led remittances affect agriculture and farming systems, we primarily focus on the latter effects of the remittance (Figure 6). Therefore, our review focuses on the agricultural dimensions of remittance utilization, though it is important to acknowledge that investments in human capital and consumption may also generate feedback loops influencing farming systems by exacerbating labor shortages, creating recursive feedback loops through remittance, and further encouraging extensification, as shown in Figure 6.

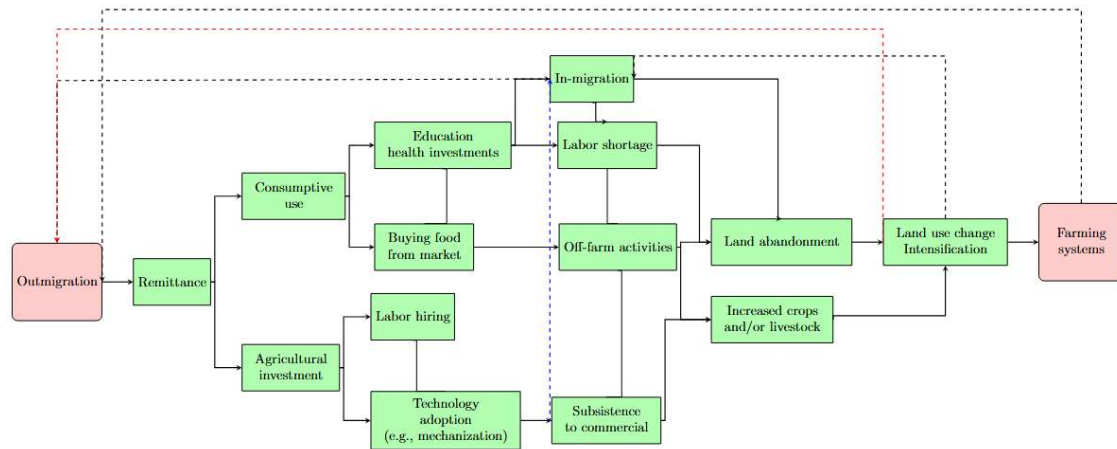


Figure 6: Pathways (green) through which outmigration-remittance influences farming systems in Nepal.

The literature consistently highlights remittance’s positive influence on Nepal’s farming systems’ transformation by counteracting migration’s negative effects on farming systems through labor shortage. In doing so, it facilitates the transition from traditional to more modern, market-oriented agricultural practices. HHs are found to invest remittances to finance mechanization, purchase improved agricultural inputs, and hire labor to compensate for workforce deficits caused by migration (Paudel et al., 2019; Bhandari et al., 2022). These investments in inputs and machinery have been found to increase crops’ yields. For instance, the adoption of mini-tillers in the mid-hill district, Palpa, resulted in a 27 percent increase (~ 0.11 Mt/ha) in rice productivity (Paudel et al., 2019), while HHs in another mid-hill district, Tanahun, reported 26 percent higher maize yield due to improved input affordability (Aryal et al., 2021; Bhandari et al., 2022). Similarly, Karki Nepal et al. (2023) found a positive contribution of remittance on the use of chemical fertilizers and irrigation, such that a unit increase in migration could be associated with 7-10 percent higher irrigation and chemical fertilizer use, respectively. When labor shortages reach critical levels, remittances enable migrant households to hire external labor for essential agricultural operations, propelling a shift from subsistence to capital-intensive cultivation (Nepal et al., 2021; Meinzen-Dick, 2022).

Beyond mechanization, remittances facilitate diversification and commercialization within the agricultural sector. HHs in Kavre and Syangja districts have invested in high-value crops like walnut and macadamia orchards, which require less labor and yield higher profits than traditional cereals (Barreto et al., 2018; Chidi et al., 2021). Similarly, livestock production has been expanded, with poultry and dairy holdings in Kavrepalanchowk increasing by 15 percent following migration-induced labor shortages (Bista et al., 2017). Notably, these benefits are not distributed equitably: high-income migrant HHs are more likely to leverage remittances for land acquisition and commercial vegetable cultivation compared to low-income HHs, thereby reshaping within-migrant household land use patterns (Khatri et al., 2023). However, there is an emerging opportunity. For instance, Cedamon et al. (2018) found that remittance-receiving HHs were likely to intensify tree growing and management on terraces and non-arable lands. The findings imply that there is an opportunity to revitalize abandoned agricultural land and promote sustainable farming systems by introducing trees and fodder along with other complementary interventions, such as livestock. A salient function of remittances is the promotion of labor-saving and yield-enhancing investments and technologies, such as irrigation infrastructure and mini tillers. For instance, Karki Nepal et al. (2023) found that HHs with each additional migrant are linked to a 10 percent rise in fertilizer use and a 7 percent rise in irrigation use, while Paudel et al. (2019) showed that remittance-led mini tiller adoptions have contributed to an average 0.11 Mt/ha yield increase among HHs with irrigation infrastructure. The yield gain is found to be highest among smallholders (≤ 0.25 ha) compared to others. Similarly, remittance has been found to be invested in irrigation infrastructure that has enabled year-round cultivation. It has been observed in Koshi Hills that migrant HHs were more likely to install pumps and canals to mitigate water scarcity during dry seasons (Pradhan & Sharma, 2017). In western districts, such as Doti and Dadeldhura, mechanization has replaced traditional oxen plowing, a change that has been especially transformative for female farmers previously restricted from using draft animals (Leder et al., 2024).

While mechanization and commercial investment have mitigated some labor constraints, their effectiveness is limited, especially in regions characterized by uneven terrain and fragmented landholdings. Moreover, in spite of remittance inflow, HHs report they abandon 7–24 percent of their land due to persistent labor shortages (Chaudhary et al., 2020; Nepal et al., 2021). In addition to downstream production challenges, farmers supported by remittances and government support to stabilize macroeconomic factors. Price volatility affected pig farmers in the mid-hill village of Khimti due to pandemic-induced feed price spikes (Khatri et al., 2023). Even when farmers directly purchase food, the food system is further vulnerable due to inflation and supply chain disruptions (Brown, 2020). Therefore, investments in food production remain a key strategy for ensuring household food security and national economy.

To augment and support remittance investments in agriculture, we propose facilitating access to financial services and agricultural extension. Our review and studies across the globe indicate that wealthier HHs with better credit access are more likely to invest in advanced technologies and commercial crops, while resource-poor farmers face persistent barriers (Pradhan & Sharma, 2017). Despite the potential of remittances to alleviate financial constraints, bureaucratic hurdles in financial services and institutional arrangements impede broader agricultural investment (Baral et al., 2021). With the strong history of cooperative structures, which enabled improved credit access and utilization—for instance, contributing to the adoption of mini tillers (Paudel et al., 2019)—rural capacities have been jeopardized post outmigration (Matthys et al., 2024).

Given the foregoing, the integration of remittances into Nepal's rural economy yields multifaceted implications for farming systems. On one hand, remittances are driving a structural transformation from subsistence-based agriculture to high-productive commercial and market-oriented models by enabling investments in mechanization, improved inputs, high-value crops, and expanded livestock production. This pathway benefits wealthier HHs. Remittances also facilitate the adoption of labor-saving technologies and empower marginalized groups, including women, to participate more actively in agricultural innovation. However, these benefits are unevenly distributed across contexts, often deepening social and economic disparities as resource-poor HHs face persistent barriers to accessing credit, extension services, and productive assets. Furthermore, the increasing reliance on remittances introduces systemic vulnerabilities, such as the expansion of fallow land due to associated labor shortages, heightened exposure to market and price fluctuations, and growing dependence on external food sources. These threaten the long-term sustainability and food sovereignty of Nepal's farming systems and underscore the urgent need for policy interventions that strategically link remittance income to agricultural credit, promote inclusive access to technology and training, strengthen cooperative and financial institutions, and develop targeted insurance mechanisms. These findings generally demonstrate positive roles of remittance in promoting farming systems intensification by promoting labor-saving technologies, mechanization (e.g., mini tiller), shifting farmers from subsistence to commercial, and enhancing resilience. In doing so, it has also helped HHs to shift from farming to off-farming activities, resulting in land abandonment and land use changes—further contributing to farming systems' extensification.

Our results contribute to framing migration in broader ecological and human behavioral discourse. The duality in migration impacts created self-reinforcing cycles that fit the postulates of the DPSIR framework, where migration acts as both driver (e.g., labor market shifts) and response (e.g., coping mechanism or safety net). Labor shortage (pressure) triggers extensification (state): land abandonment, land use change, forest succession, and crop and livestock de-intensification (impact) stand relatively high in mountains and hills due to topographic constraints and feminized labor reallocation, where women take expanded responsibilities but face social and cognitive barriers (Rana et al., 2018; Rai et al., 2019). In contrast, remittance (response) enables intensification (state) through capital substitution, promoting higher climate-tech adoption and mechanization and contributing to crop yields (Paudel et al., 2019; Maharjan et al., 2021). The findings are consistent with Structural Transformation Theory (Basu, 2000; Timmer, 2009; De Haas, 2021) and NELM's emphasis on migration as a HH reallocates its human resources in the non-agricultural sector, influencing extensification, while remittance inflows contribute to mechanization, thereby promoting intensification. With these behavioral theories, we identified motives and orientations for low-income HHs (risk-averse) either to (i) leave land fallow or (ii) take low-labor subsistence as presented in Kahneman & Tversky (2013), while high-income HHs (risk-takers) pursue high-value diversification as explained in Ajzen (1991). Feminization intensifies this gap as women are empowered with leadership roles (e.g., Water User Associations), but they are to take additional workloads, compromising real decision-making power.

Conclusions, policy implications and limitations

The systematic review analyzes the drivers and impacts of migration on agriculture and draws implications for the farming systems. We search literature using online databases, including Scopus, and develop search terms in English. Identified articles were screened for relevance using inclusion and exclusion criteria following PRISMA protocol, resulting in 43 papers from a pool of 45,402 articles after screening based on publication year, geographical scope, and relevant themes. Reviews demonstrate two main channels through which migration affects farming systems: (i) it leads to labor shortages in rural areas, increases feminization by redefining gender roles and responsibilities, and surges land abandonment; (ii) it offers remittance inflows to left-behind families to resolve budget constraints, reduces reliance on local agricultural practices, and provides capital to invest in labor-reducing technologies, shifting HHs from subsistence to commercial agriculture.

We further observe inducement in labor dynamics, technological adoption (e.g., mechanization), gender equity, production, environment/ecology, social inequality, and resulting dual effects in Nepal's farming systems: de-intensification and intensification. Our findings highlight the need for targeted countermeasures in response to the dual effects of migration mentioned. To address this duality, policies should combine topographic-specific interventions with Nepal's existing agricultural support systems by (i) establishing migrant-inclusive mechanization to sustain intensification and (ii) creating gender-responsive agroforestry incentives in hills/mountains to counter extensification. These measures should be integrated into Nepal's National Adaptation Plan (NAP) and Agricultural Development Strategy, which currently overlook migration's spatial disparities but must expand to support risk-averse smallholders through fallow land management while enabling risk-taking households to invest remittances in high-value diversification. Simultaneously, Nepal's community forestry and WUAs can address feminization gaps by combining women's leadership roles with workload-reduction technologies. This dual-pathway approach,

recognizing migration as both driver and response, offers a framework to transform labor and remittance flows into sustainable farming system transitions. Prioritizing spatial, social, and gender equity is critical to harnessing migration for resilient agricultural transformation (Aryal et al., 2020; Meinzen-Dick et al., 2022).

We note some limitations with this systematic review and directions for future studies. First, the review only focuses on and prioritizes HH-level responses to migration and thus overlooks macro-scale inequalities, such as caste, hierarchies, land tenure systems, and policy failures, that can shape differential outcomes. Second, the review primarily captures cross-sectional dynamics (about 70 percent) with less focus on long-term feedback cycles between migration and farming systems, such as recursive vulnerability and delayed ecological impacts on HHS' farmland use behaviors, their income, and their livelihoods, which limits the findings' causal inference. Third, the review poses publication biases toward hills and Terai and underrepresents mountain farming systems and may overlook upstream-downstream linkages and the flow of ecosystem services. Future studies should underscore the need for longitudinal, mixed-methods research to clarify how migration reconfigures farming systems across spatial and social fabrics by closely examining the above aspects. By incorporating these limitations, Nepalese farming systems and others with similar contexts can navigate the complexities of outmigration and build a resilient, inclusive, and sustainable farming future. These caveats notwithstanding, we believe that this study can be considered as a necessary first step to review and assess migration's dual effects on farming systems from HHS' perspective and contributes to farming systems literature and sustainability.

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Appendix

Appendix 1: The reviewed articles, respective journals and their impact factors.

SN	Citations	Title	Journal Name	JIF ²	Study objectives	Data type ³	Sample size	Farming systems' indicators
1	Gartaula et al. (2012)	Socio-cultural dispositions and wellbeing of the women left-behind: A case study of migrant HHs in Nepal	Social Indicators Research	2.8	To understand objective and subjective wellbeing by exploring the perceptions of women left behind by out-migrating husbands on their quality of life in a transnational social field	CS	277	Subject and objective wellbeing
2	Piotrowski et al. (2013)	Farming Systems and Rural Out-Migration in Nang Rong, Thailand, and Chitwan Valley, Nepal	Rural Sociology	1.9	To examine agricultural push factors determining the out-migration of young people	CS	876	land tenure, crop portfolios, animal husbandry activities, use of farm inputs
3	Tuladhar et al., (2014)	Effects of migration and remittance income on Nepal's agricultural yield	ADB Working Paper Series	NA	To analyze the effects of migration and remittances on agriculture yield	CS	2947	Paddy yield
4	Jaquet et al. (2015)	Does outmigration lead to land degradation? Labour shortage and land management in a western Nepal watershed	Applied Geography	5.4	To assess the effects of male outmigration on land abandonment and land degradation	CS	546	Land use,
5	Pradhan and Sharma (2017)	Land use change and its driving forces in the Koshi Hills, Eastern Nepal	Springer Geography	NA	To analyze the change in land use and land	DI	—	Land use, land cover
6	Shrestha et al. (2017)	Earthquake mitigation and its effect on eco-environment and social development: A case study from Tamakoshi river basin of central mountain region, Nepal	Springer Geography	NA	To analyze the impact of migration on poverty, expenditures, and labor market outcomes in Nepal	P	976 village	Poverty, expenditure, and labor
7	Barrueto et al. (2018)	What prompts agricultural innovation in rural Nepal: A study using the example of Macadamia and walnut trees as novel cash crops	Agriculture	3.6	To investigate the determinants of rural innovation, using macadamia and walnut trees as examples	CS	279	Walnut and Macadamia production
8	Mukherji et al. (2018)	Megatrends in Hindu Kush Himalaya: Climate Change, Urbanisation and Migration and Their Implications for Water, Energy, and Food	Water Resources Development and Management	2.2	To examine the current and future megatrends from a mountain perspective, assessing the impacts for water, energy, and food security of glacial melt, altered river flows and	R	—	Economic development, environmental sustainability, water, energy,

² JIF indicates Journal Impact Factor for 2024 in reference to <https://mjl.clarivate.com/>.

³ LP = Longitudinal, CS = Cross-sectional, DI= Digital Image, P = Panel, R = Review

SN	Citations	Title	Journal Name	JIF ²	Study objectives	Data type ³	Sample size	Farming systems' indicators
9	Prassain (2018)	Climate change adaptation measure on agricultural communities of Dhye in Upper Mustang, Nepal	Climatic Change	4.8	drying springs, coupled with unplanned urban growth and outmigration To evaluate the potential adaptation measures to avoid CC-induced migration	CS	26	Farming coverage and herd size
10	Rana et al. (2018)	Examining agency in agriculture: The feminization debate in Nepal	Journal of International Women's Studies	NA	To explore how HH members' everyday lifestyles regarding agriculture and non-agriculture shape their lives differently	CS	140	Crop and livestock ownership, citrus production
11	Cedemon et al. (2018)	Contribution of integrated forest-farm system on HH food security in the mid-hills of Nepal: assessment with EnLiFT model	Australian Forestry	1.2	To analyze the relationship of HHs' livelihood resources and agroforestry practice in relation to out-migration and remittance	CS	668	Crop and livestock ownership, citrus production
12	Paudel et al. (2019)	Smallholder farmers' willingness to pay for scale-appropriate farm mechanization: Evidence from the mid-hills of Nepal	Technology in Society	12.5	To analyze smallholder farmers' willingness to pay (WTP) for purchase of scale-appropriate farm mechanization in the hill ecologies of Nepal	CS	628	Mechanization, WTP, demand
13	Poudel et al. (2019)	Scale-appropriate mechanization impacts on productivity among smallholders: Evidence from rice systems in the mid-hills of Nepal	Land Use Policy	5.9	To analyze the impacts associated with adoption of mini tillers	CS	1004	Min tiller adoption, rice yield
14	Rai et al., (2019)	Status of Farmland Abandonment and Its Determinants in the Transboundary Gandaki River Basin	Sustainability	3.3	To examine the status of farmland abandonment, its trends and determinants in Mountain, Hills and Gangetic Plain of Gandaki Basin	CS	639	Farmland abandonment
15	Brown et al. (2020)	The Effects of Male Out-Migration on Food Security and Food Sovereignty in Rural Nepal	SIT digital collection	NA	To analyze the impacts of out-migration on food sovereignty and insecurity in rural Nepal and their differential impacts across socioeconomic groups	R	—	Labor supply, Land abandonment, Food security, Food sovereignty,
16	Chaudhary et al. (2020)	A synopsis of farmland abandonment and its driving factors in Nepal	Land	3.2	<ul style="list-style-type: none"> To assess the spatiotemporal extent of farmland abandonment in Nepal To explore driving factors of farmland abandonment, and To discuss eco-environmental and sociocultural consequences in Nepal 	R	—	Land abandonment, Production of goods and services

SN	Citations	Title	Journal Name	JIF ²	Study objectives	Data type ³	Sample size	Farming systems' indicators
17	Gautam et al. (2020)	Do earthquakes change the timber and firewood pattern of the forest dependent HHs? Evidence from rural hills in Nepal	Forest Policy and Economics	3.8	To assess the types of shocks faced by the earthquake-hit HHs and the change in timber and firewood use patterns by them before and after the occurrence of devastating Gorkha earthquake-2015 in Nepal	P	99	Timber and firewood use patterns
18	Poudel et al. (2020)	Farmland abandonment and its determinants in the different ecological villages of the Koshi river basin, central Himalayas: Synergy of high-resolution remote sensing and social surveys	Environmental Research	7.7	To assess the status of land abandonment and to examine its differential impacts across spatial and socioeconomic contexts	DI, CS	167	Land abandonment
19	Rijal et al. (2020)	Quantifying the drivers of urban expansion in Nepal	Environmental Monitoring and Assessment Sustainability	3.0	To explore the factors affecting land use and land cover changes and urbanization.	CS	200	Land use, land cover
20	Wang et al. (2020)	Land use and land cover change detection and prediction in the Kathmandu district of Nepal using remote sensing and GIS	World Development Perspectives Technology in Society	3.3	To detect and predict land use and land cover changes in one of the world's most vulnerable and rapidly growing city of Kathmandu	DI	—	Land use, land cover
21	Kapri and Ghimire, (2020)	Migration, remittance, and agricultural productivity: Evidence from the Nepal Living Standard Survey	World Development Perspectives Technology in Society	2.3	To analyze the relationship between migration, remittances, and agricultural productivity using microdata from Nepal	CS	1414	Agricultural productivity
22	Aryal et al. (2021)	Mechanisation of small-scale farms in South Asia: Empirical evidence derived from farm HHs survey	Sustainability	12.5	To investigate the mechanization process undertaken in South Asia – India, Nepal and Bangladesh	CS	2528	Mechanization use
23	Baral et al. (2021)	Human wildlife conflict and impacts on livelihood: A study in community forestry system in mid-hills of Nepal	Journal of Mountain Science	3.3	To investigate the impact of Human Wildlife Conflict on people living near community forests (CF) in Nepal	DI	811	Land cover change, Human Wildlife Conflict events
24	Chidi et al. (2021)	Land use intensity dynamics in the Andhikhola watershed, middle hill of Nepal	International Journal of Disaster Risk Reduction	2.5	To analyze the land use intensity change and to identify its major determining factors	CS	—	Land use intensity
25	Nepal et al. (2021)	Geospatial approach to the risk assessment of climate-induced disasters (drought and erosion) and impacts on out-migration in Nepal	Frontiers in Sociology	4.5	To explore the impacts of climate-induced disasters on migration in Ramechhap district of Nepal and their effects of resilience	R	100	Resilience – capacity to recover
26	Rasul et al. (2021)	Socio-Economic Implications of COVID-19 Pandemic in South Asia: Emerging Risks and Growing Challenges		2.2	To examine the existing and prospective impacts, risks and challenges of Covid-19 on key social and economic sectors including migration, tourism, informal sector, agriculture and rural livelihood		—	Food systems

SN	Citations	Title	Journal Name	JIF ²	Study objectives	Data type ³	Sample size	Farming systems' indicators
27	Maharjana et al. (2021)	Can labour migration help HHHs adapt to climate change? Evidence from four river basins in South Asia	Climate and Development	3.4	To examine the impacts labor migration on adaptation to climate change	CS	1987	Adaptation
28	Bhandari et al. (2022)	Land Cover Change and Its Impact in Crop Yield: A Case Study from Western Nepal	Scientific World Journal	NA	To analyze the land cover change over two decades, the migration effect in land cover, and the impact caused in crop production	CS	250	Land cover change, crop production
29	Bista et al. (2022)	Impacts of COVID-19 pandemic on the livelihoods of rural HHHs in the community forestry landscape in the Middle Hills of Nepal	Trees, Forests and People	2.9	<ul style="list-style-type: none"> To examine the differential impacts of COVID-19 among the socio-economic groups To examine how do return migrants affect the rural land use To explore whether returnee migrants put additional pressure on forests resources 	P	2015	Land abandonment, Livestock number, Forest product uses
30	Maraseni et a., (2022)	Impact of COVID-19 in the forestry sector: A case of lowland region of Nepal	Land Use Policy	5.9	To assess the impact of COVID-19 on the forestry sector of Nepal	KII	—	Agroforestry, Home gardening, Livestock, Innovation
31	Meinzen-Dick et al. (2022)	Migration and Gender Dynamics of Irrigation Governance in Nepal	International Journal of the Commons	1.9	To examine the effects of male migration on institutional change in local agricultural institutions, women's roles, technological change, and outcomes affecting effectiveness of irrigation systems	CS	336	Institutional change, women's roles, technological change, effectiveness of irrigation systems
32	Atreya and Gartuala (2022)	Changing gender role declines maize yield, but remittances offset: Findings from migrant HHHs in the central Himalayas, Nepal	Outlook in Agriculture	2.6	To investigate the interplay between labor out-migration, changes in gender roles, and their effects on the	CS	1053	Farm income, non-farm income
33	Karki Nepal et al. (2022)	International labour migration, farmland following, livelihood diversification and technology adoption in Nepal	International Labour Review	2.6	To investigate the effect of temporary international migration on farmland following, adoption of intensification technologies and livelihood diversification	CS	3843	Farmland following, adoption of intensification technologies, livelihood diversification
34	Doss et al. (2022)	Women's empowerment, extended families and male migration in Nepal: Insights from mixed methods analysis	Journal of Rural Studies	5.7	To identify differences in norms and practices regarding property rights for different castes and ethnic groups and their relative effects of caste, ethnicity and HH structure on women's empowerment	CS	188	Women's empowerment

SN	Citations	Title	Journal Name	JIF ²	Study objectives	Data type ³	Sample size	Farming systems' indicators
35	Shahi et al. (2022)	Forest—People nexus in changing livelihood contexts: Evidence from community forests in Nepal	Trees, Forests and People	2.9	To explore the changing livelihood strategies of forest users and analyses their effects on participation in forest management	CS	106	Participation in forest management
36	Timilsina et al. (2023)	Assessment of land use land cover dynamics and its impact on springs water in Ritung Khola Sub-Watershed, Myagdi district, Nepal	Eurasian Journal of Soil Science	NA	To determine the rate in change in land cover and its impacts on springs water in the Ritung Khola of Nepal in between 2010 and 2020	DI	—	Land use land cover
37	Khatri et al. (2023)	Why is farming important for rural livelihood security in the global south? COVID-19 and changing rural livelihoods in Nepal's mid-hills	Frontiers in Human Dynamics	1.3	To provide rich, place-based data on experiences and impacts of COVID-19 and associated economic disruptions on HH farming strategies	LP	240	Farming type, cultivated land (fallowing), subsistence production, income (remittance),
38	Rai et al. (2023)	Appraisal of Empirical Studies on Land-Use and Land-Cover Changes and Their Impact on Ecosystem Services in Nepal Himalaya	Sustainability	3.3	To appraise the empirical studies on land-use and land-cover changes and their impact on ecosystem services in Nepal Himalaya	R	90	Land-use, land-cover change (LULCC), Ecosystem services (ESs)
39	Matthys et al. (2023)	The Role of High-Value Agriculture in Capability Expansion: Qualitative Insights into Smallholder Cash Crop Production in Nepal, Laos and Rwanda	European Journal of Development Research	2.6	To analyze the contributions of high-value agriculture to human capital formations.	CS	150	Paid work,
40	McGunnigle et al., (2023)	The Succession of Farmers' Perceptions of Transitioning Landscapes – A Case Study of Agroforestry in the Middle Hills of Nepal	Human Ecology	2.7	To understand the perceptions of forest succession on agricultural land abandonment in mid-hills of Nepal	PL	300	Perception and attitude on land use change
41	Leder at al. (2024)	Rural out-migration and water governance: Gender and social relations mediate and sustain irrigation systems in Nepal	World Development	5.8	To investigate the impact of rural out-migration on collective action in farmer-managed irrigation systems, with a particular focus on HH structure and gender relations	CS	377	Collective action on irrigation systems
42	Smith et al. (2024)	Out-migration, agricultural abandonment, and community forest management: Drivers of afforestation in privately managed land in Nepal	Applied Geography	5.4	To examine the contribution of afforestation on land abandonment and its adjustment with outmigration	DI	—	Land abandonment
43	Poudel et al. (2024)	De-agrarianisation and re-agrarianisation in patches: understanding microlevel land use change processes in Nepalese smallholder landscapes	Forest, Trees and Livelihoods	1.7	To understand the exit and entry to agriculture across social and spatial landscapes.	LS	153	Land idling, agrarian change, subsistence farming, wildlife

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This research was conducted as part of the CGIAR Sustainable Farming Science Program. This research is being implemented by CGIAR researchers from CIMMYT. CGIAR is a global research partnership for a food-secure future. Its science is carried out by 15 Research Centers in close collaboration with hundreds of global partners. www.cgiar.org

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