Prospects for Farm Mechanization in Mid-hills of Nepal

Stakeholder Experiences and Vision

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The Mixed Farming Systems Initiative aims to provide equitable, transformative pathways for improved livelihoods of actors in mixed farming systems through sustainable intensification within target agroecologies and socio-economic settings.

Through action research and development partnerships, the Initiative improves smallholder farmers' resilience to weather-induced shocks, provide a more stable income and significant benefits in welfare, and enhance social justice and inclusion for 13 million people by 2030.

Activities are implemented in six focus countries globally representing diverse mixed farming systems as follows: Ghana (cereal–root crop mixed), Ethiopia (highland mixed), Malawi: (maize mixed), Bangladesh (rice mixed), Nepal (highland mixed), and Lao People's Democratic Republic (upland intensive mixed/ highland extensive mixed).

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Abbreviations and acronyms

ABC	Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT)
ADS	Agriculture Development Strategy
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
GESI	Gender and Social Inclusion
ICARDA	International Center for Agricultural Research in the Dry Areas
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
KII	Key informant interview
MFS	Mixed Farming Systems
SWOT	Strengths, Weaknesses, Opportunities and Threats

1 Background

In addition to modern seeds, fertilizers and cultural practices, farming has been revolutionized and modernized through mechanization by making farming less labour-intensive, Since the first invention of seed drill in seventeenth century - with controlled spacing and depth, which increased yields and reduced seed loses - machines are increasingly used instead of humans, However, in most parts of developing world, farmers still rely on manual operations. Most cited limitations include suitability, useability and cost. In Nepal, a review by Takeshima and Justice (2020) traces the use of 4 and 2-wheel tractors in lowland regions to 1970s, quadrupling by 1990s, and tripling by 2000s. Since then, there has been exponential but insignificant growth in machinery usage restricted to larger lowlands farms. A decade ago, mini-tillers designed for small farms were introduced and recorded a 10-fold increase between 2005 and 2016 (Takeshima & Justice, 2020).

To spur modernization and commercialization of the agricultural sector, the government of Nepal has set policy goals and developed strategies including Nepal's Agriculture Mechanization Policy (2014) and Agriculture Development Strategy (ADS, 2015-2035) that promote use of scale-appropriate mechanization technologies. The government and stakeholders are increasingly investing in mini tillers (2-wheel hand tractors) that are appropriate for the hill zone as well as labour-saving low energy implements and mechanized irrigation that expand the mechanization frontier to the mountain zone (Takeshima et al., 2016). Despite these ambitions and progress, the practical implementation of mechanization policies remains inconsistent, particularly in the mid-hills, where small and irregular terraces make the use of conventional machinery difficult. Tailoring machinery to landscapes and socio-economic profiles is therefore essential to fit varied topography, feminization of labour, and diversity of cropping systems, which have been limiting (Devkota et al., 2020).

This research note explores the current state of farm mechanization in the mid-hills of Nepal, examining the strengths, weaknesses, opportunities, and threats of existing mechanization support programs while identifying key policy and practical recommendations for future interventions. By doing so, this research contributes to aligning policy with local needs, scoping capacity gaps, and identify inclusive machinery services that are accessible to smallholder farmers, including women, youth and marginalized groups.

2 Methodology

This study employed review of existing practices and trends related to farm mechanization in the mid-hills of Nepal through integration of three approaches on a sequential basis (Figure 1). Data were gathered from relevant programs and projects focusing on mixed farming systems, supplemented by insights from experts working in agricultural research and development sectors. Particular attention was given to the mechanization experiences in Khotang district in east and Surkhet district in the west, representing the mid-hills.

To gain a deeper understanding of the challenges and opportunities associated with mechanization, stakeholder consultations and key informant interviews (KII) were conducted in 2024. Participants included representatives from different tiers of government, market actors, machinery suppliers, and local farmers. These discussions addressed key questions such as budget allocation for machinery, prioritization of specific machines, perspectives on subsidy programs, capacity gaps in mechanization, and potential impacts of policy changes on machinery adoption.

In addition to formal interviews, we documented observations on the attitudes and perceptions of stakeholders involved in the machinery supply chain and the insights drawn from the field visits. This qualitative approach helped capture the nuances of how mechanization is perceived and implemented at the local level, providing valuable context for the analysis of mechanization support programs and their alignment with the needs of smallholder farmers in the mid-hills.

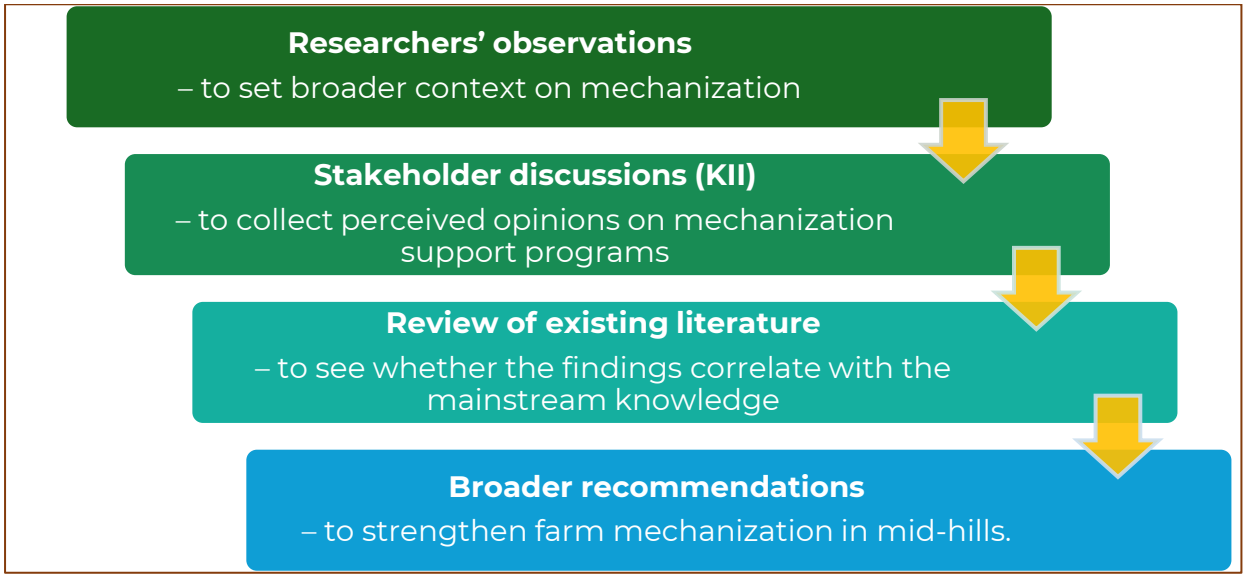

Figure 1 Workflow of the qualitative study in mechanization in mid-hills of Nepal.

3 Findings and discussions

3.1 Technological innovations and terrain challenges

In the mid-hills of Nepal, the difficult terrain characterized by small, irregular terraces limits mechanization options. Although four-wheel tractors are available, a large proportion of tractors are being used for transporting goods especially off-farm products, construction, sand mining and so on rather than for on-farm operations (Gauchan & Shrestha, 2017). Mini-tiller adoption, however, is increasing rapidly, becoming almost synonymous with farm mechanization in the mid-hills. Despite its growing importance, the mini-tiller's utilization is constrained by the region's topographic challenges.

Mini tillers are predominantly used for tillage in relatively flat areas of mid-hills, but they remain inaccessible to most terraced lands on steep slopes, where traditional crop cultivation for subsistence continues. These terraces, crafted and maintained by farming households over generations, were originally designed for bullock-driven plough and manual cultivation, including traditional harvesting methods. This raises a critical question: are the small, irregular terraces of the sloping hills suitable for machines like mini tillers or reapers? Farmers from Halesi Tuwachung Municipality and the local machinery trader mentioned that all terraces are not suitable for the use of mini-tiller and the reaper is even more difficult to operate in these lands.

The stark elevation differences in these terraces make operating machines like hand tractors (mini-tillers or power tillers) exceedingly difficult. In comparison to bullock ploughing, bullocks and wooden ploughs are more manageable for farmers. Bullocks are well-trained to navigate the terraced landscape, and the wooden plough is much lighter and easier to carry. In contrast, current mini-tiller models are heavy and cumbersome, making them difficult to transport even within a single farm. Furthermore, the high percentage of stones in the soil poses additional challenges, as metal parts of modern equipment struggle to handle such conditions effectively. This reality calls into question the assumption that mini tillers are the most suitable machinery for farming in the hill landscape.

Another misconception pertains to the provision of machinery services in the hills. The difficulties in transporting and operating mini tillers on terraced lands often undermine programs aimed at establishing custom hiring centres in the region. Many of these initiatives fail, resulting in inactive or underutilized machinery service centres that struggle to provide sustainable services beyond the duration of the programs.

However, this does not imply that mechanization in the mid-hills is an unattainable dream. To promote the effective use of machines and machinery services, there is a pressing need to reorient technological priorities and shift existing mindsets. By developing equipment better suited to the unique conditions of the mid-hills and fostering innovative service models, mechanization can become a viable and transformative reality for farmers in this challenging terrain.

3.2 Policy implementation gaps

As specified in Agriculture Development Strategy (ADS) 2015-35, farm mechanization is a nationally prioritized sub-sector in agriculture in the current decade. Nepal's Farm Mechanization Policy 2014 prioritize scale-appropriate mechanization and services focusing on small-holder farmers including women.

The agricultural extension bodies and experts tend to emphasize provision of financial support through the budgeted activities are mostly being planned and implemented in a distributary model making the agricultural extension entities like subsidy distribution centres. (Khatri & Shrestha, 2023) For instance, the Agriculture Knowledge Center (AKC) aka '*Krishi Gyan Kendra*' once established under the provincial government to provide expert services to the farmers/stakeholders has become Agriculture Subsidy Center aka '*Krishi Anudan Kendra*'. Even the bureaucrats claim the same but are compelled to do so either because of political pressure or due to lack of management and technical capacity of the concerned staff to devise meaningful interventions, meaning that budget is allocated in trivial regular type of activities. The existing power dynamics at different levels play an important role in targeting interventions rather than considering technical suitability of any intervention to the locality.

While devising and implementing activities for the extension offices where particular technical persons are assigned to do his/her job, the followings play crucial role in influencing the budget allocation and implementation:

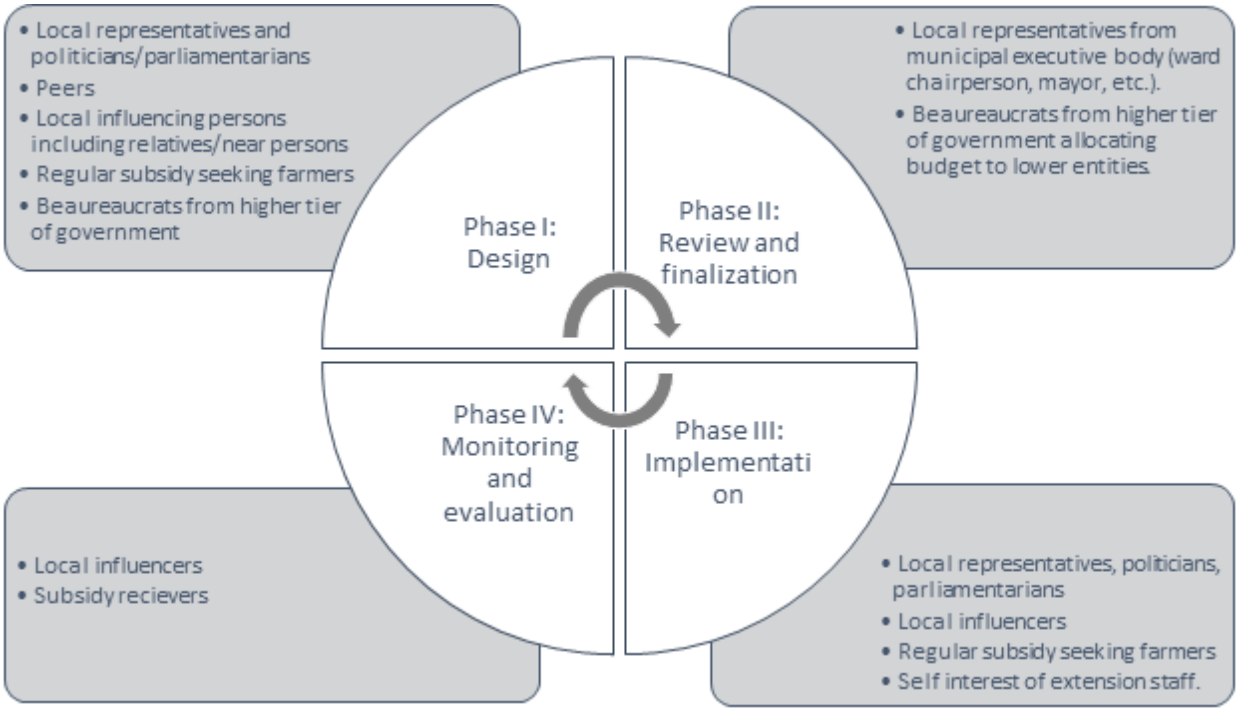

Figure 2 Process of designing activities at the local extension offices and the influencers

The diagram indicates the role of different actors in the whole process of activity designing to implementation. With close guidance of representatives, extension officers prepare the activity list for the next fiscal year cycle, which is further scrutinized by representatives and other bureaucrats from administration before finally submitting to the executive council meeting at local level. The executive council meeting reviews and approves the budgeted activities with adjustments, if any. This process in local government helps to streamline activities tailored to the local needs through in-depth consultation between various bodies. However, the actual outcome of this process depends on how the different government bodies or personnels are taking it seriously to serve the farming communities. In many cases, the activities might be targeted to the areas as a tool of pork-barrel politics (Khatri & Shrestha, 2023) where the politicians/representatives have comparative advantage for their career.

On the flip side, some technologies are targeted based on the characteristics of the farming system and land suitability. It was observed that mini-tillers are widespread in lowland areas of Surkhet while grinding mills are seen dominantly distributed in steeper areas of Khotang with comparatively fewer number of mini-tiller users.

3.3 Gender and mechanization

Sustainable intensification practices that reduce the use of resources like water, fertilizer and energy, should be supported by mechanization in small scale farms of South Asia (Aryal et al., 2021). Among the several, they identified four important factors (male headship, excess to credit and extension services, economic status and training) having larger impact on adoption of mechanization technologies. Gender and farm mechanization are crucially important in current contexts of rural mid-hills of Nepal, where labour shortage is experienced due to male out-migration (Gartaula et al., 2023).

Especially in the mid-hill regions of Nepal, mini tillers are increasingly prioritized by support programs (Gurung et al., 2017). Although being women-friendly, issues like spare-parts unavailability and difficulty in transporting the machine in terraces have largely reduced the utilization and scope of the machine (Kafle, n.d.). Additionally, significant gender gap is reported between male and female-headed households in terms of adoption of mechanization options including mini tiller in the mid-hills of Nepal (Paudel et al., 2020). Enhancing market access and female-headed households targeted policies and programs are recommended as a measure of reducing the adoption gap. Despite the pronounced gap, (Paudel et al., 2019) highlighted the role of small-scale mechanization by adopting mini tillers in increasing rice productivity up to 27% in the mid-hills of Nepal, while non-adopters would be able to enhance productivity by 26% if they adopt the mini tiller machine for land preparation.

Although claimed to be women-friendly, stakeholders mentioned that different brands of small machines like mini tiller available in market are still difficult to operate by the women farmers (Gartaula et al., 2023). For instance, most mini tillers are heavy and shaky during operation. Most women farmers need

assistance from the male members of their family to start the engine and transport machine to the fields especially in the terraced fields.

3.4 Economic and market dynamics

The successful adoption of machinery technology depends on different elements including farm size, local wage rate, outmigration status, access to credit facilities, number of draft animals, and linkage with cooperatives (Paudel et al., 2019). Except the number of draft animals, all factors are positively associated with willingness to pay (WTP) of the smallholder farmers in mid-hills of Nepal. Unlike seed and fertilizers, the machinery interventions including mini-tillers are capital-intensive indicating the low willingness to pay by the farmers up to less than 31% of the actual price of the machine (Paudel et al., 2019). Since farm size is positively correlated with willingness to pay, farmers having very few chunks of land have less willingness to pay indicating to prioritize service provision models to make the machinery service available to the very small farmers. The question is whether the service provision model fits in mid-hill's mixed farming systems where the difficult topography limits the movement/transport of machines.

With increasing trends of farm mechanization in Nepal, significant research works have been undertaken and reported/published generating evidence in agricultural mechanization sector. (Devkota et al., 2020) identified small-scale mechanization's supportive hands in alternative innovation pathways for sustainable development of farming in hills. Although mentioned about scale-appropriate mechanization, the existing mechanization policies that prioritize so-called 'industrialization' in flat areas are largely unclear how mechanization is promoted in hills and mountains.

Despite having fast progress of machinery supply chain in Nepal, machinery market chain in mid-hill regions is still at incipient phase. Machinery suppliers are mostly confined to district headquarters and in some cases provide services from other districts. Moreover, after-sales services have been limitedly available in mid-hills, posing challenges in long-term utilization of machinery purchased through subsidies or full investment by the individual farmers. This situation demands more in-depth analysis of the contexts of mid-hills considering challenges and opportunities of machinery market system development.

3.5 SWOT Analysis of current government support scheme

Strengths	**Weaknesses**
▪ Prioritized farm mechanization as its core theme which is dire need of the present. ▪ All three tiers of government have been providing support benefitting large number of farm communities in different commodities. ▪ Pivotal in introducing new machines and with the demonstrated effect helping to establish supply chain of proven machineries. ▪ Providing cash subsidy on mechanization helping to reduce machine hiring cost and help balance the rental cost within farming locality due to increased number of machinery service providers. ▪ Government prioritizing cooperatives and farmer groups have substantial reach to the farming households. ▪ Providing government support has increased leadership and management skills of the beneficiary farmers and groups.	▪ Incorrect allocation of prioritized areas for the support schemes based on political influences. ▪ Path-dependent bureaucratic network that ignores innovative processes of support schemes. ▪ Problem in spending allocated budget due to managerial incompetence. ▪ Lack of adequate human resources at project management and implementation units. ▪ Lack of proper machinery operation, management, and maintenance skills among technical staff. ▪ No gender responsive budget provisions in the support schemes. ▪ Less emphasis on supply chain strengthening of machinery in most of the government programs. ▪ Inappropriate agriculture extension practices including imposition of technologies to farmers without persuasion. ▪ Lack of coordination among local, provincial and federal governments. ▪ Support activity implementation not synchronizing with seasons or not in time.
Opportunities	**Threats**
▪ There is possibility of increased market demand and supply of farm machineries due to heavy subsidy schemes which in turn helps to strengthen machinery supply chain. ▪ Some correctly identified and operated zones and super zones could be the examples of success establishing a good market chain of commodity crops. ▪ Support programs like PMAMP are heavily prioritizing mechanization, so the learnings from the project can be useful for future project interventions both for government and non-governmental organization.	▪ Chances of flourishing corrupted mentality and rent-seeking attitude among bureaucrats due to heavy flow of funds with no proper supervision and auditing. ▪ Failure to sustain the progress at the later period of the support programs with reduced budget allocation can be evident as priority is not given in market system development. ▪ Subsidy schemes can be highly misused by some of the elite people (so called farmers) unless support programs like PMAMP adopt suitable measures to increase access of poor and needy farmers. ▪ Increased dependency of farmers towards subsidy schemes which may affect the market in short and long run due to subsidy-waiting mentality.

4 Conclusions and recommendations

Mechanization in the mid-hills of Nepal requires a context-specific, holistic approach due to the diverse needs of the region's mixed farming systems. The current emphasis on mini tillers overlooks the importance of mechanization in fruit cultivation and livestock management. To reduce drudgery - particularly for women - machinery should focus on tasks like harvesting fodder or transporting farm commodities in difficult terrains. Given the region’s vulnerability to soil erosion, reduced tillage technologies should be prioritized. Transitional solutions, such as seed drills for bullock-driven ploughs, can ease the shift towards more advanced mechanization. Policies must be revisited to reflect the unique landscape and farming practices of the mid-hills, ensuring that machinery development and infrastructure investments cater to local needs.

Capacity building, transparent governance, and gender-sensitive approaches are critical to ensuring successful mechanization. Government support must extend beyond equipment distribution to include technical training for farmers and extension officials, enabling effective use and maintenance of machines. Machinery suppliers should also receive training in client-focused business strategies and be supported in developing mobile mechanic services. Additionally, mechanization must be inclusive of women farmers, with gender-responsive budgeting and tailored capacity-building programs to enhance access to and confidence in using mechanization tools. A coordinated effort among policymakers, suppliers, and farming communities will ensure that mechanization boosts productivity while addressing the unique socioeconomic and geographical challenges of the mid-hills.

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