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Improved Farmyard Manure Management in Nepal's Mid-Hills: Opportunities and Barriers

By

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THESIS

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MASTER OF SCIENCE

in

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Abstract

In the mid-hills of Nepal, improved farmyard manure (FYM) practices are being promoted to support crop productivity, soil health and climate resilience. However, little is known about farmer adoption, particularly with respect to recent socioeconomic changes including increasing out-migration and labor shortages. This mixed-methods study integrated survey data (n=413 and n=82) and semi-structured farmer interviews (n=21) to (i) assess current FYM management strategies and adoption of best FYM practices, (ii) analyze farmer perspectives to identify barriers and opportunities for achievement of best practices, and (iii) interpret the results within a sustainable livelihoods framework to identify opportunities for targeted farmer support. Key trends were identified across four major FYM processes: 1) FYM availability is limited by reductions in large livestock, 2) farmers prioritize livestock shed improvements to increase efficiencies but this also presents some trade-offs, 3) there is limited adoption of improved FYM storage practices, and 4) farmers strive to increase the efficiency of FYM field application, often integrating it with inorganic fertilizers, but face multiple challenges. Using the sustainable livelihoods framework, the most frequent farmer-reported barriers and opportunities were human capital (knowledge and labor) as well as physical, financial and natural capital. Notably, social capital emerged as a fundamental enabler for the other capitals, and capacity to improve FYM management was impacted by structural factors related to social networks and access. These results, centered on farmer voices, help identify opportunities for targeted farmer engagement to overcome specific barriers, with a focus on increasing access to social, human and other livelihood capitals that facilitate FYM improvement.

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1. Background

1.1 Agricultural context: Nepal's mid-hills

Nepal is a country rich in natural resources and agricultural traditions. More than half of the national workforce is employed in farming, with a majority (75%) on small subsistence or minimally commercialized farms of less than 0.5 ha (National Statistics Office, 2023a; Ministry of Agricultural Development, 2016). While the country contains diverse and extreme agro-ecological zones as well as swiftly changing socio-economic dynamics, most farming systems have traditionally integrated forest, livestock and crop management to achieve productive sustainability (Tripathi et al., 2022). The mid-hills are one of the three major agroecological zones in Nepal, making up 42% of the nation's total area and 15% of cultivated land, and housing 40% of the population (Fig. 1; National Statistics Office, 2023a; Krupnik et al., 2021).

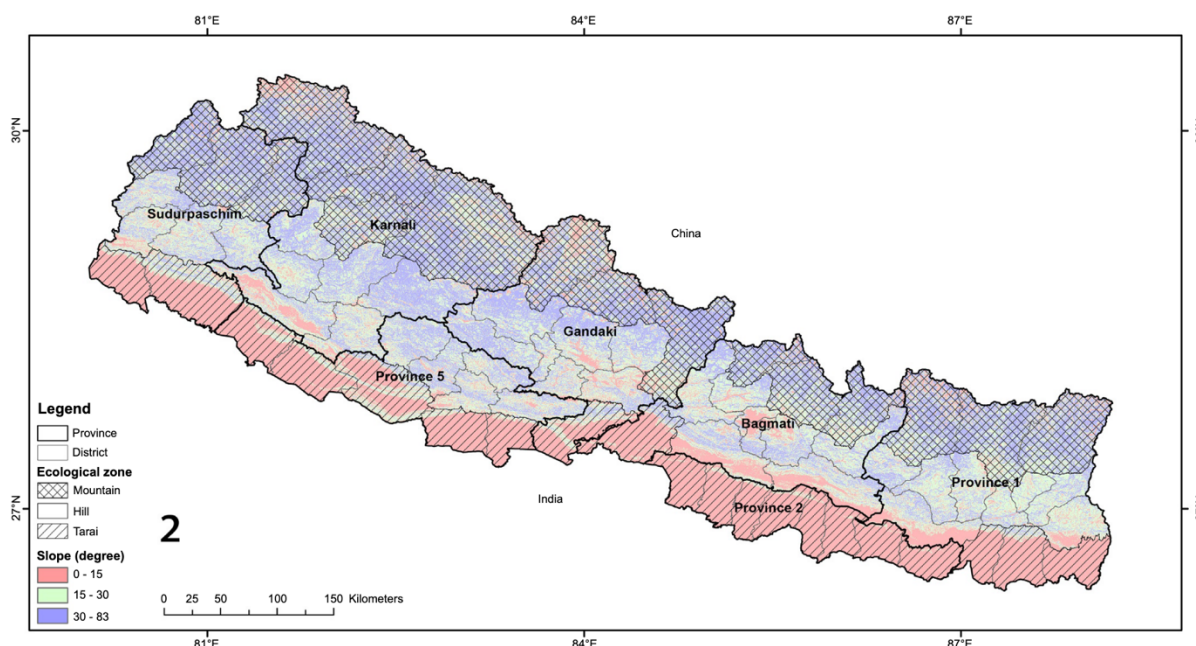


Figure 1. Map of Nepal's agroecological zones. From Krupnik et al., 2021.

Despite significant investments in agricultural development, Nepal faces profound ecological and socio-economic challenges to food system resilience. Agricultural productivity is low, and crop yields have not responded significantly to efforts to modernize the agricultural sector (Devkota et al., 2019; Joshi et al., 2021). In the last two decades, the country has shifted from net-export to net-import of agricultural products including staple grains (Khanal & Thapa, 2023). Agricultural production has also decreased as a portion of the national economy, from 66% of GDP in 1970 to 23% in 2020 (Nepal Planning Commission & World Food Programme, 2019; Timsina et al., 2022). Meanwhile, local people, especially those in rural and remote communities, face hardship: around 13% of the population experiences severe food insecurity and 25% of children under five are stunted due to malnutrition (World Bank, 2024).

Out-migration of farmers, who are unable to make a sustainable living in agriculture and seek employment abroad, has accelerated in recent years with significant impacts. As of the 2021 census, approximately 23% of the Nepali population were living abroad, and 82% of those absent individuals were male. The economy's dependence on remittances sent from overseas has grown since 2000, making up 26% of GDP in 2024 (World Bank, 2024). Out-migration from rural areas has resulted in severe labor shortages and increased rates of land abandonment, threatening rural livelihoods and food security on the one hand, but also providing new opportunities associated with remittance income on the other hand (Maharjan et al., 2020; Gartaula et al., 2012; Tiwari & Joshi, 2015). Because agricultural work has traditionally been sorted by gendered labor norms, the significant loss of male labor has resulted in a reshaping of roles, often referred to as “feminization of agriculture” (Kandel et al., 2026; Gartaula et al., 2010). Women who stay behind often experience increased workload, expansion of on-farm decision-making and participation in community (Maharjan et al., 2017). This trend has

differentially impacted agricultural production, depending on a number of factors including women's control of remittance income (Maharjan et al., 2017; Gartaula et al., 2010).

1.2 Soil health and farmyard manure (FYM)

Across Nepal's diverse agro-ecosystems, farmers face challenges to maintain soil health and crop productivity (Chalise et al., 2019). In the harsh climate and landscape of the mid-hills, nutrient mining, declining soil organic matter content, and soil erosion limit agricultural production and reduce resilience to the impacts of climate change (Subedi et al., 2015; Jat et al., 2022). As farmers seek to modernize and intensify agricultural systems, traditional management practices that have historically maintained soil health are declining in favor of input-dependent methods. (Subedi et al., 2015; Dhakal & Escalante, 2022). In the 2015-2035 Agricultural Development Strategy (ADS), the Government of Nepal identified soil health improvement as a key area of action, aiming to increase average soil organic matter across the country from 2% to 4% and decrease degraded soils nationwide 50% by 2035 (Ministry of Agricultural Development, 2016).

Farmyard manure (FYM) is a key source of soil fertility, used by an estimated 78% of farmers in the mid-hills (Chaudhary et al., 2022). FYM is a traditional, locally produced soil amendment composed of composted mixed livestock manure, animal feed and bedding residues, forest litter, and other organic wastes. Although farmers have increased their use of inorganic fertilizers (from an average of 6 kg/ha in 2006 to 68 kg/ha 2023), application rates are still low compared to other countries in South Asia due to access and affordability challenges (Dhakal & Escalante, 2022; World Bank, 2024). Even as input availability improves, FYM continues to play an important role in mid-hill farming systems by increasing crop yields, profitability, soil organic matter, and biological activity, while reducing erosion and building soil structure to

resist impacts of climate change (Dhakal & Escalante, 2022; Pilbeam et al., 2003; Tiwari et al., 2009; Zaller & Kopke, 2004). Locally available, renewable resources like FYM can also be powerful tools for sustaining community resilience by limiting dependence on purchased inputs (Joshi, 2025). Many farmers in Nepal blend FYM with purchased inorganic fertilizers, but often lack the information, labor and resources needed to do so effectively (Krupnik et al., 2021; Ministry of Agricultural Development, 2016).

Despite its traditional significance and biophysical benefits, FYM use has declined (Bajracharya et al., 2007; Aryal et al., 2021; Acharya et al., 2007) and common practices for FYM storage and management result in significant nutrient loss (Subedi et al., 2015). Farmers invest significant labor and time in FYM management, but often do not yield expected results. FYM is often managed simply: as much of the livestock in the mid-hills are raised in/around the farmstead (not on pasture) for much of the year, farmers gather manure and other livestock residues from the shed area as convenient. These residues are then stored in open piles, exposing the contents to sun, air and heavy rain, where they often decompose unevenly. In this kind of open storage, Reddy et al. (2015) found that 39% of the nitrogen, 20% of the phosphorus and 32% of the potassium can be lost through leaching and volatilization pathways. When the time for field preparation nears, this FYM is often carried to the cropping fields in back-mounted *doko* baskets as time allows and placed in small piles, again exposed to the elements until it is time to plow and plant.

To reduce nutrient losses and improve the efficacy of farm-produced FYM, a number of best practices for FYM management have been developed and promoted by the Government of Nepal and several NGOs (SSMP, 2001; ICIMOD, 2020; FAO, 2012; LI-BIRD, n.d.). These best practices, which draw from traditional and new methods, include:

1. Livestock sheds have a roof, solid floor, and channels for urine separation/collection (to be diluted and used as liquid fertilizer).
2. FYM storage is protected from all sides from sun, wind and heavy rain. This may take the form of a pit or heap with a roof or plastic sheet covering.
3. FYM is turned or mixed to facilitate full decomposition.
4. After transport to the field, FYM is incorporated quickly or stored in a protected pile until time is available to spread and quickly incorporate.

Evidence from Nepal and beyond supports these improvements, with Bishwakarma et al. (2014) finding that adoption of the package of best practices increased soil organic matter over 3 years by 0.5%, and farmers reported positive co-outcomes like improved moisture retention, easier tillage and increased yields. FYM protection by covering with plastic is one of the most effective strategies, reducing N and C losses, increasing crop-available N, and increasing yields (Rufino et al., 2007; Shah et al., 2012; Tripathi & Ellis-Jones, 2002) Urine separation (to be applied separately to crops) also significantly reduces N volatilization (Rufino et al., 2007; Sun, 2025).

1.3 Socioeconomics and FYM

Research has investigated the impact of socioeconomic issues on farmer adoption of FYM in general, often in combination with other sustainable management practices in South Asia, yet there is a significant knowledge gap regarding how and why farmers might adopt the specific FYM recommendations above. The broader literature provides some insights, but effects of demographic and household characteristics are complex and mixed: older farmers and households with more members are more likely to apply FYM, while higher educated farmers opt into other sustainable practices like IPM and reduced tillage but are less likely to apply FYM (Aryal et al., 2021; Begho et al., 2022; Karna et al., 2020). Farmers with more land and livestock

apply more FYM, but impacts of household income are also mixed (Begho et al., 2022; Begho et al., 2024; Karna et al., 2020; Aryal et al., 2021; Chaudhary et al., 2022). Due to substitution of livestock with machinery, mechanization is negatively correlated with FYM usage (Chaudhary et al., 2022). Information access is one of the most important drivers, and engagement with extension services greatly increases farmer adoption of FYM and other composting practices (Aryal et al., 2021; Dhakal & Escalante, 2022). Factors that build social capital and connection like participation in farmer cooperatives increases FYM use, and having neighbors and friends that adopt improved composting methods increases a farmer's likelihood of adoption (Aryal et al., 2021; Dhakal & Escalante, 2022). These findings generally originated from large-scale farmer surveys with statistical models including numerous explanatory variables, which are useful to identify population-level drivers, but do not provide a nuanced understanding of the diversity of farmer experiences and perceptions.

Especially given the trends of male out-migration and agricultural feminization in Nepal, major uncertainties remain about how gender dynamics influence the adoption of FYM recommendations. Many of the tasks associated with FYM, including livestock care and FYM transport, are traditionally completed by women, and thus changes in the gender labor balance are anticipated, leading to positive or negative outcomes. For example, while the loss of male agricultural labor increases women's workload, it also leads in some cases to increased female decision-making and increased financial capabilities through remittance income (Gartaula et al., 2010; Kandel et al., 2015). Spangler & Christie (2019) find that the effects of agricultural feminization in Nepal are not straightforward; female farmers' ability to take advantage of potential benefits from male-outmigration is highly dependent on particular factors including their access to community networks and relationships outside the household like farmers' groups

and cooperatives. The research on adoption of FYM by female farmers reflects the challenges they face: Aryal et al. (2021) find that female-headed households apply less FYM, and Dhakal & Escalante (2022) that female farmers are less likely to adopt improved composting practices.

To support broader implementation, it is key to understand the degree to which recent recommendations for improved FYM management require extra knowledge, resources, and labor, which bring additional barriers surrounding the potential for adoption. By specifically focusing on adoption of improved FYM practices rather than FYM usage only, I address a critical gap in the existing literature. Within this context, my research brings together two larger survey datasets from farming households in mid-Western hills of Nepal with a set of in-depth follow-up interviews to understand the complexity of factors shaping farmer decision-making about FYM management. This allowed me to address these major research objectives within the changing socioeconomic context: 1) Assess current FYM management strategies and adoption of best FYM practices, 2) Analyze farmer perspectives to identify barriers and opportunities for achievement of best FYM management practices, and 3) Interpret the results within a livelihood capitals framework to identify opportunities for targeted farmer support.

2. Methods

2.1 Research design and theory

In his research, I employ a mixed-methods approach that analyzes farmers' perspectives to outline current FYM management practices in Nepal's smallholder farming systems and understand the barriers and opportunities that shape those practices. Following Creswell's explanatory sequential design for mixed-methods research (Creswell, 2022), I began this study by analyzing two previous household-plot surveys (n=413 and n=82) completed by CGIAR. I

then conducted my own in-depth interviews with a smaller, purposefully sampled subset of participants (n=21). The household surveys provided information on farm characteristics (Zepeda et al., 2023) and FYM-related metrics across Gurbhakot Municipality (Mponela et al., 2025), which in turn were used to guide the development of the interview themes and identify farmers for follow-up interviews.

By inviting farmers' voices into the research process, this methodology helped provide detailed context of farmer experiences, circumstances, and decision-making, helping further explain and extend the survey findings. Similar sequential mixed-methods approaches have been found to enhance farmer response and reveal likely actions and perceived barriers (Limon et al., 2014), understand how underlying gendered vulnerability and inequality shape decision-making (Khoza et al., 2022), or attitudes towards information sharing (Haris et al., 2018). Directly focusing on farmers' perspectives is rooted in a long history of "farmer first" methods (Chambers, 1989.; Klein et al., 2024; Scoones & Thompson, 1994). These argue that farmers' own expertise, experience, and innovation are fundamental to successful agricultural technology development and that farmers must lead the way by "identify[ing] their own priorities" (Chambers, 1989, p. xx). All research activities involving human participants were reviewed and determined exempt (minimal risk) by the UC Davis Institutional Review Board.

2.2 Study region

This study is based in five wards of Gurbhakot, a municipality in mid-Western Nepal (Figure 2). These communities are clustered along the floodplains and hills surrounding the Bheri River, which runs down the eastern valley of Surkhet district, in the southernmost and lowest-elevation part of Karnali Province (200-1600 m). Agriculture is a dominant occupation in the area, with 96% of households engaged in farming, and the major crops grown are rice, maize

and wheat (Laing et al., 2023). Out-migration is a common experience, as 36% of households in Surkhet district have at least one member absent (either residing inside Nepal or abroad), and 89% of those out-migrants are male (National Statistics Office, 2021).

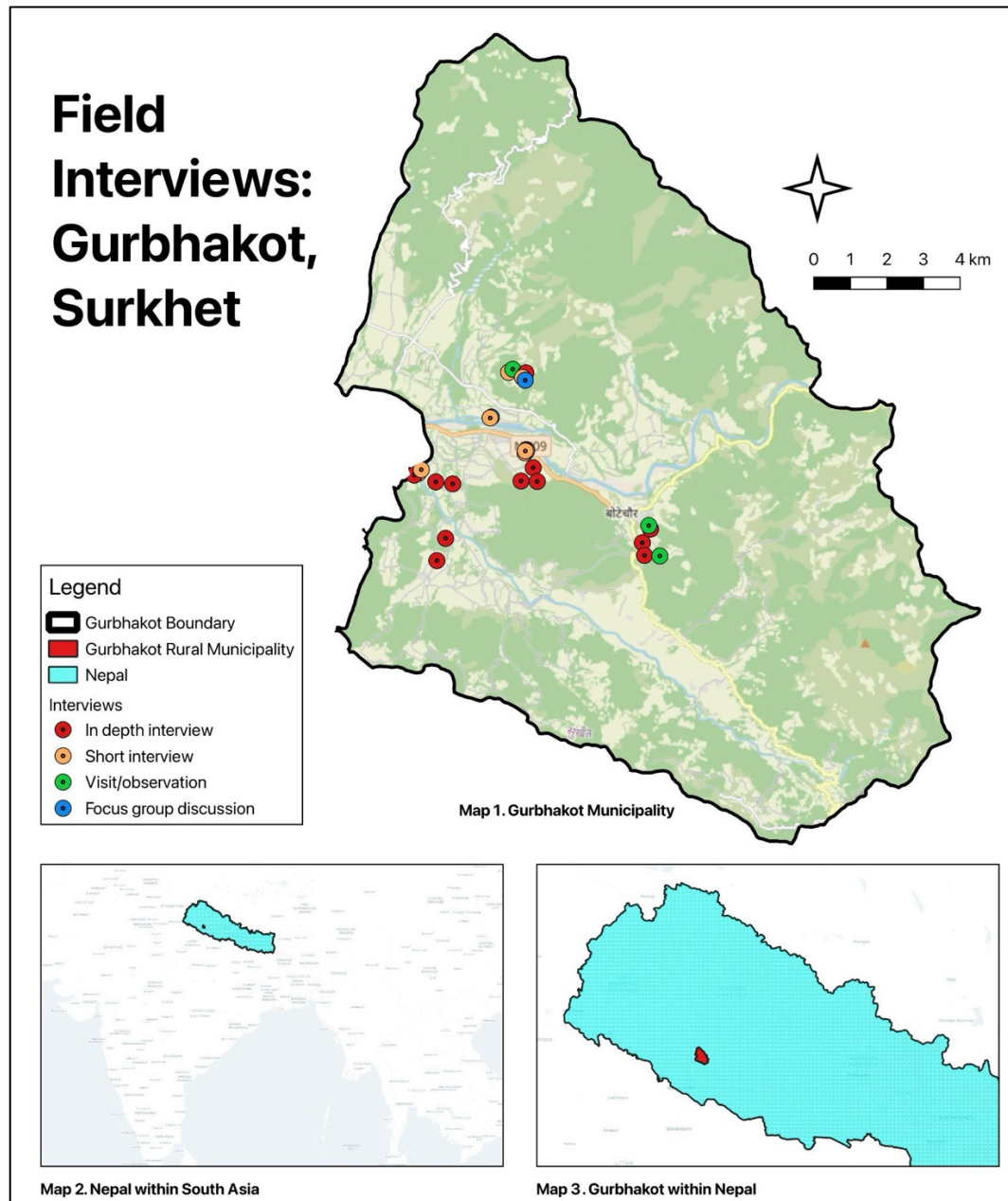


Figure 2. Map of research area and interviewed farms

2.3 Data collection

Regional trends

Previously, two rounds of surveys were conducted by the CGIAR Mixed Farming Systems Initiative in 2023 (Zepeda et al., 2023) and 2024 (Mponela et al., 2025). The first used stratified random sampling to survey 413 households in Gurbhakot, gathering information on household demographics, farm activities and economics (including crop and livestock management), climate experiences, and future plans. The aim of this survey was to shed light on regional farming system dynamics to identify potential areas of additional research and support. The following variables are reported at the household level in Table 1: household head gender and education, per capita household income, total farmed area, household out-migrants, experiences of food insecurity and labor shortage, livestock population, share of household income from livestock sources, and manure available per hectare farmed. Livestock population is measured in Tropical Livestock Units (TLU), which assigns 1 TLU per approximately 250 kg animal. Annual household FYM availability was approximated using an estimate of 3.9 Mg fresh manure produced per TLU (FAO, 1992). FYM and fertilizer use on rice and maize was calculated as a binary variable and is visualized in Figure 4.

The follow-up survey (2024) collected information about FYM-specific practices and resources in a subset of 82 households from the first survey. Households representing diverse farming systems were asked about specific FYM practices including livestock populations, components of FYM, FYM application rates and crops, and FYM storage and management practices. From this survey, the percentage of households adopting different FYM practices (FYM storage structure (pit vs pile), FYM covering in storage, FYM turning, and urine collection) are reported in Figure 3. These two studies provide background for mine.

Farmer decision-making

With the assistance of a Nepali co-researcher from CIMMYT, I conducted semi-structured interviews with 21 previously surveyed farmers to understand their perceptions and decision-making related to FYM, helping identify barriers and opportunities in FYM management. Interviews were conducted between June-August 2025 in wards 6, 7, 8, 9 and 12 of Gurbhakot municipality (Figure 2) using a purposive farmer selection process. A working list of 70 potential interviewees was drawn up from the previous survey pool to include households with a range of FYM practices and household head genders, providing a diversity of perspectives and farm types. Full length semi-structured interviews (30-65 min) were completed with 12 of these pre-selected farmers and shorter interviews (20-30 min) with 4 others. At times, farmers directed us towards nearby farmers using compelling practices; in these cases, data were collected from them in the form of a short interview (20-30 min; 2 completed) or a field observation (2 completed). After completing interviews in the planned area, we visited an additional part of Gurbhakot Municipality (ward 12) that had not been previously surveyed, but had a different geography, placed high on a hill above the river, to expand the diversity of farm types in the sample. In ward 12, 1 long interview, 2 short interviews, and 1 field observation were completed.

The semi-structured interviews were guided by an interview protocol with broad themes (warm-up, FYM knowledge and perceptions, current FYM practices, barriers and opportunities, time/labor/resource dynamics, and goals/recommendations) and sub-questions inspired by the framework of Barrier Analysis, which is designed to elicit responses about the many determinants that shape respondents' behaviors (Kittle, 2017). See Appendix A for the full interview format. They were also shaped by the findings of the two regional surveys and related

literature. The interview guide and methods were reviewed by multiple members of the research team to improve the quality of the questions and the ease of the interview process. Interviews were conducted in the local Nepali language, simultaneously translated into English by a Nepali research partner, and also audio recorded. The interview guide provided a framework, but the conversations were allowed to flow organically with the farmers' responses and priorities; to reduce time load on farmers, we did not touch on all topics with all respondents. During each interview, I took English-language notes on the interview form to record farmer responses, non-verbal cues and add contextual information. The short interviews and group discussions were not recorded; instead detailed field notes were taken *in situ*. These were typed up and expanded with additional detail soon after completion of each field day.

In ward 12, a group discussion was also conducted with approximately 18 women in a local mother's group to reflect on present practices and identify barriers and opportunities for possible FYM improvements; illustrations of the "best FYM practices" were used to aid in conversation (see Appendix B). Upon completion of all field interviews, a reflection session was conducted with a group of five municipal agricultural officials.

2.4 Data management and analysis

All field data were anonymized and processed according to data type. The full-length interviews were first transcribed from mixed-language audio to English text using web-based transcription tool TurboScribe, then edited for accuracy first by a Nepali-speaking member of the research team, and finally by a Surkhet-based Nepali research assistant. Expanded field notes from short interviews and group discussions were also prepared for analysis. All qualitative data were uploaded to qualitative data analysis software Dedoose in the form of an interview transcript (long interviews) or interview form/field notes (short interviews, group discussions).

The qualitative data analysis was guided by the framework of thematic analysis, which follows a set of logical steps to draw reliable conclusions from the complexity of open-ended interview data using codes (Braun & Clarke, 2006; Boeijs, 2002.). By drawing on deductive and inductive methods, I developed codes shaped by existing theory and literature while also remaining responsive to the respondents' words (Creswell & Creswell, 2017; Proudfoot, 2023). Coding was completed in three passes. First, an initial read of all data was conducted to re-familiarize with the content and create a list of starting thematic codes. Second, data were coded by theme and, when relevant, by the type of dynamic being described (opportunity, barrier, adaptation, or change). On the third pass, codes were consolidated for clarity and focus, and simultaneously many excerpts were co-coded with a "capital type" related to the dynamic at hand (financial, labor, knowledge, practical, other resources) (Bourdieu, 1986).

Household variables for interview data (farmer gender and age group, household head gender and education level, number of working adults, farmed area, number of livestock, manure availability, and tillage mechanization) were quantified and are displayed in Table 2. TLU and estimated FYM available per hectare were calculated as above. The adoption of FYM and fertilizer practices (pit vs pile storage, covered FYM storage, FYM turning, urine separation, and FYM vs inorganic fertilizer use in rice and maize) are reported alongside corresponding survey data in Figures 3 and 4.

Coded excerpts and key quotes from the interviews were organized by process type (livestock husbandry, shed practices, FYM management practices, and field application) or by theme (migration and generational changes, attachment to agriculture, decision-making, gender/marginalization, and farmer ideas/needs). Many codes were then identified as "barriers" or "opportunities" contributing to dynamics that shape FYM improvement within the four major

FYM processes (Table 3). To understand the relative significance of these codes within the interviewed farmer group and categorize them under broader driving forces, I ranked them by the number of farmers reporting each theme. To interpret the complex data, I sorted these barriers and opportunities by driving “livelihood capital” (Figure 5), based on the Sustainable Livelihoods Framework (Chambers, 1992; Chambers, 1995; Scoones, 1998; Nararajan et al., 2021). The five livelihood capital types – human, financial, physical, natural, and social – allowed us to further examine the intersectional relationships between farmer experiences, barriers faced, and opportunities for targeted farmer support.

2.5 Researcher positionality

As a white, educated woman from the United States, I brought a specific set of experiences and perspectives that shaped all facets of the project, including the research questions themselves, my access to research resources and relationships, my engagement with research partners, and my interpretation of data. My identities and structural privilege shaped how participants perceived me and influenced the knowledge generated through the research process. I am clearly an outsider to the research context, and I entered the research space with power both from my structural positioning and from my institutional connections (UC Davis and CIMMYT Nepal). At the same time, my previous experiences living and working in the rural global south, including Nepal for more than two years during my Peace Corps service, and my comfort with the language spoken by the research participants (Nepali), provided contextual familiarity that facilitated relationship-building and provided some foundational understanding of local livelihoods. My background working on organic farms in the United States and my academic interest in agroecological frameworks directed my line of questioning towards ecological agriculture and community resilience, rather than industrial, input-reliant systems. I

am committed to asking questions and doing research that can create change in the world, in this case helping agricultural communities build power, produce healthy food, and sustain livelihoods. These stances, and many others, impacted my research and its findings.

3. Results and discussion

3.1 Farm-household characteristics and FYM practices

Among the surveyed households (n=413), 70.1% were headed by males and 29.3% by females (Table 1). Of the heads of household, 37% had no formal education, 33% had primary education, 28% had secondary education, and 1.7% had post-secondary education. In almost half of households (44%), at least one member out-migrates for at least 6 months of the year, and 15% of the households had more than one out-migrant. Household incomes varied widely, with a median annual household income of 119,287 NPR (~\$805 USD (in 2026)), and 54% of the surveyed households falling below the local poverty line of 55,505 NPR/person/year (National Statistics Office, 2024). Ninety-seven percent of these households reported worrying about food availability, quality or affordability sometimes or frequently. The average household farmed an average of 0.4 hectares, made 11% of its income from crops, 25% from livestock-related sources, and the remaining from off-farm sources. Seventy-six percent reported experiencing an on-farm labor shortage at some point during the prior year.

In the larger survey (n=413; Fig. 1), farms have a mean TLU of 0.79 for large livestock (buffalo, cows and oxen) and 0.36 for goats and sheep. These livestock produce an estimated average of 12.68 Mg/yr of fresh manure per hectare farmed. Most farmers apply both FYM and

Table 1: Household and farm data: 2023 Farm characterization survey (n=413) among farm households in Gurbhakot Municipality, Surkhet. NR is No Response. The local poverty line (rural Karnali province) is 55,505 Nepali Rupees/person/year (National Statistics Office, 2024). 1 Tropical livestock unit (TLU) ~ 250 kg animal weight. Fresh manure is calculated at a rate of 3.9 mt/yr/TLU.

Household characteristics	n (%)
Household head gender	
Female	121 (29%)
Male	292 (71%)
Household head education level	
No formal	152 (37%)
Primary school	138 (33%)
Secondary school	116 (28%)
College	7 (2%)
Per capita annual household income	
Very low (<50% poverty line)	148 (36%)
Low (51-100% poverty line)	76 (18%)
Low-middle (101-150% poverty line)	32 (8%)
Middle-high (151% poverty line and above)	58 (14%)
NR	101 (24%)
Farmed area (ha)	
0.05-0.2	113 (27%)
0.3-0.5	186 (45%)
0.6-0.99	104 (25%)
>1	10 (2%)
Household out-migrants (6 months or more)	
0	231 (56%)
1	122 (30%)
>1	60 (14%)
Worry about food security	
Never	14 (3%)
Sometimes	143 (35%)
Yes	256 (62%)
Experience labor shortage at some point during the year	
Yes	315 (76%)
No	98 (14%)
Livestock and manure	
Tropical Livestock Units (TLU) (large livestock only)	
0 (None)	202 (49%)
0.7 (1 large animal)	73 (18%)
1.4-2.1 (2-3 large animals)	109 (26%)
>2.1 (4 or more large animals)	29 (7%)
Share of household income from livestock	
<1%	136 (33%)
1-25%	59 (14%)
26-50%	59 (14%)
51-75%	21 (5%)
>75%	37 (9%)
NR	101 (24%)
Fresh manure available per hectare (Mg/ha/yr)	
None	75 (18%)
Low (1-10 Mg)	152 (37%)
Medium (11-20 Mg)	102 (25%)
High (>20 Mg)	84 (20%)

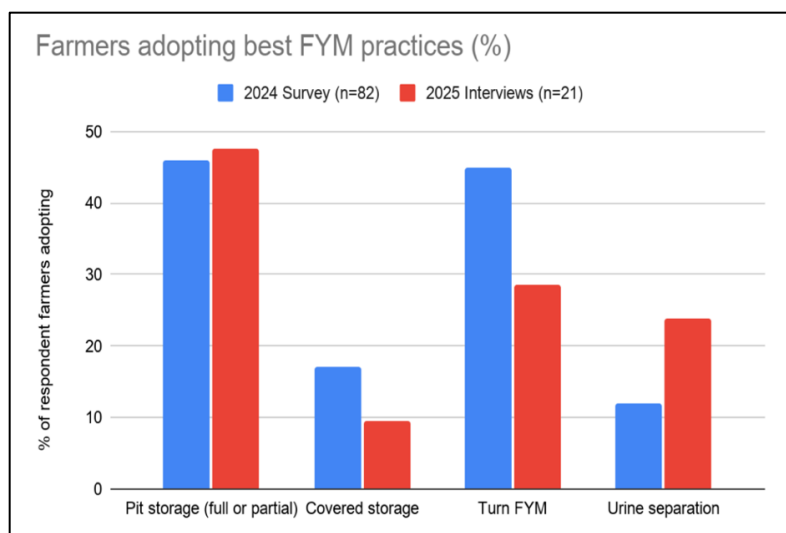


Figure 3: Farmers adopting best FYM practices (%). Survey data from 2024 (n=82) and interview data from 2025 (n=21).

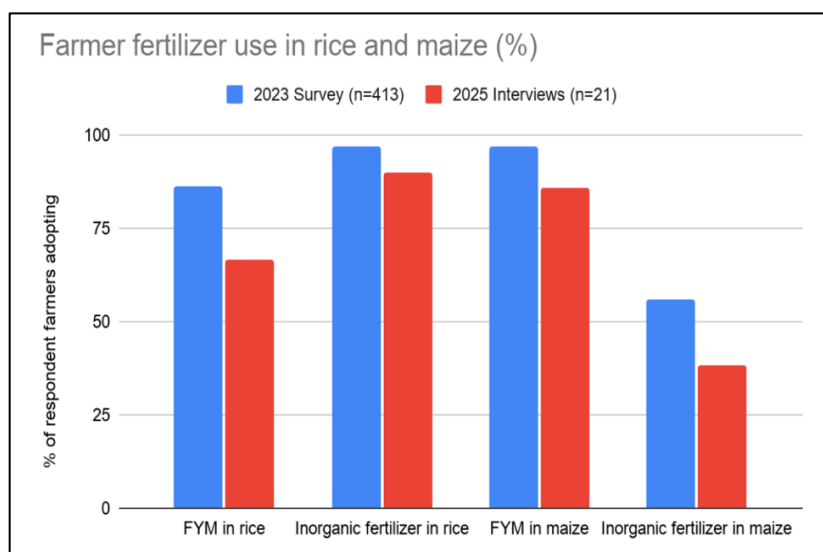


Figure 4: Farmers applying FYM and inorganic fertilizer on rice and maize (%). Survey data from 2023 (n=413) and interview data from 2025 (n=21).

inorganic fertilizer (urea and/or DAP) depending on the crop (Fig. 4). For rice, 86% of responding farmers apply FYM and 97% apply inorganic fertilizer. For maize, the practice is opposite: 97% apply FYM and 56% apply inorganic fertilizer.

The follow-up survey provides data specifically on improved FYM management and storage practices (Fig. 3). Among the 82 farmers, 46% store their FYM in a pit (partial or full),

17% use covered FYM storage, 45% turn their FYM at some point during storage, and 12% separate livestock urine from the FYM pile.

3.2 Interview data

Four components of the FYM process

Household and farm characteristics for the 21 interviewed farmers are reported in Table 2. As farmers described their FYM management practices and decision-making that shape FYM quantity, quality, and efficiencies, their process sorted into four component parts, each with distinct trends, barriers, opportunities and impacts (Table 3). These are (A) livestock husbandry, (B) livestock shed management, (C) FYM management, and (D) field application.

A. Livestock Husbandry

Because most farmers in this study rely on manure produced solely by household livestock, the quantity and types of livestock kept by farmers are the most fundamental determinants of FYM availability. In the interviewed group, the mean TLU is 2.8. Every household keeps livestock of some kind: 11 households have one or more adult buffaloes, 8 have juvenile buffaloes, 4 have cows, 10 have oxen, and 18 have goats and/or sheep (with 3 keeping only goats/sheep). Fowl (chickens and ducks) were not counted in this study.

Reductions in livestock

A majority of the farmers interviewed (n=13) reported that they have fewer livestock and/or smaller livestock now than they did in the past. The most common change is scaling back populations of dairy buffalo, which per animal produce the highest quantity and quality (according to interviewed farmers) of locally-available manure. Labor availability is the most significant barrier to retaining buffalo: 10 farmers reported that they have insufficient time to care for buffaloes, which are considered the most time-intensive livestock due to high

Table 2: Household and farm data from interviewed farmers (n=21). Interview data from households in Gurbhakot, July 2025. NR is No Response. 1 Tropical livestock unit (TLU) ~ 250 kg animal weight. Fresh manure calculated at a rate of 3.9 mt/yr/TLU.

Household and farm characteristics	n (%)
Farmer gender	
Female	8 (38%)
Male	5 (24%)
Mixed group	8 (38%)
Farmer age group	
Youth (15-34)	4 (19%)
Middle aged (35-54)	15 (71%)
Elder (55 and up)	2 (10%)
Household head gender	
Female	3 (14%)
Male	18 (86%)
Household head education	
No formal	5 (24%)
Primary	2 (10%)
Secondary	8 (38%)
Post-secondary	1 (5%)
NR	5 (24%)
Number of adult household members working on farm	
1-2	7 (33%)
3-4	9 (43%)
>4	1 (5%)
NR	4 (19%)
Households with out-migrants	
Yes	14 (67%)
No	4 (19%)
NR	3 (14%)
Farmed area (ha)	
0.2-0.5	8 (38%)
0.6-0.9	5 (24%)
>1	3 (14%)
NR	5 (24%)
Livestock and manure	
Tropical Livestock Units (TLU) (large livestock only)	
0 (None)	5 (24%)
0.7 (1 large animal)	4 (19%)
1.4-2.1 (2-3 large animals)	9 (43%)
>2.1 (4 or more large animals)	2 (10%)
Tillage practices	
Ox traction (owned)	10 (48%)
Two-wheel tractor (owned)	3 (14%)
Two-wheel tractor (hired)	11 (52%)
Both oxen and tractor	5 (24%)
NR	2 (10%)
Fresh manure available per hectare (Mg/ha/yr)	
None	0 (0%)
Low (1-10 Mg)	9 (43%)
Medium (11-20 Mg)	5 (24%)
High (>20 Mg)	2 (10%)
NR	5 (24%)

Table 3. FYM processes overview. Based on interviews with 21 farmers, there are four key FYM processes each with 2-4 component practices. The table presents each practice's current trend, impacts of that trend on FYM and nutrient management and opportunities and barriers to adoption.

FYM Process	Practice	Trend	Impacts on FYM	Opportunities	Barriers
Livestock husbandry	Keeping dairy buffalo	decrease	Less manure	- Market for milk - Need for manure - Fodder planting (irrigation)	- Labor scarcity (fodder collection) - Fodder scarcity - Financial scarcity - Mechanization of field work
	Keeping oxen	decrease	Less manure	- Need for oxen-based tillage - Oxen used for certain field operations - No \$/expertise for tractor	- Mechanization of tillage - Labor scarcity (caring for oxen, conducting oxen tillage)
	Shifting from large to small livestock (buffalo calves, goats)	increase	Less manure	- Market for buffalo meat - Easier to manage than large livestock - GoN programs for goat husbandry	- Labor scarcity - Fodder scarcity - Financial scarcity
Shed management	Improved sheds (roof, cement floor and troughs, fodder cutting machine)	increase	Easier FYM management, feed efficiency, livestock welfare	- GoN outreach and subsidy - Farmer motivation - Neighbor knowledge sharing	- Labor scarcity - Financial scarcity
	Quantity of non-manure residue (bedding, fodder refuse)	decrease	Less FYM; some report increased FYM quality	- Continued use of traditional methods (abundant bedding) - Access to jungle resources	- Reduced access to jungle resources (restrictive management, labor scarcity, fear) - Trade-offs of improved fodder management (less feed refuse)
FYM management	Pit storage	some adoption	For farmers using pits: decreased nutrient loss	- Neighbor knowledge sharing - Extension/training	- Logistical challenges with pit - Knowledge gap
	Turning/mixing FYM	little adoption	Incompletely composted manure	- Desire for fully composted manure	- Knowledge gap - De-prioritization
	Covering FYM	little-no adoption	Nutrient loss from FYM in pile	- Maintaining traditional practices (covering FYM with organic materials) - Training/extension or travel to other areas	- Knowledge gap of nutrient loss in FYM storage, and possible - No knowledge of covering practices - Scarcity (resources/money/labor)
Field application	Quantity FYM applied	decrease	Lower yields; soil degradation and erosion	- Increased/sustained livestock - Farmer knowledge (traditional)	- Fewer/smaller livestock - Less non-manure material in FYM
	Efficient timing of FYM application/incorporation	increase	Decreased in-field nutrient loss from FYM	- Farmer knowledge (neighbor networks, outreach programs) - Access to tillage equipment	- Unreliable irrigation access - Labor scarcity, challenging shared labor arrangements
	Substitution with inorganic fertilizers	increase	If insufficient, nutrient mining, decreased yields, soil degradation/erosion	- Less FYM available - Shift to rice (less FYM applied to rice)	- Knowledge of FYM benefits - Belief that chemicals are harmful
	Integration with inorganic fertilizers	increase	Dependent on quantities/balance; possible increased yields and soil health	- Farmer knowledge - FYM availability	- Less FYM available

feed and daily milking requirements. Farmers noted that their families are smaller (often due to out-migration), they have other tasks associated with off-farm work or businesses that take up their time, and/or they are getting too old to take care of buffaloes. When asked why they have few or no buffaloes, farmers responded:

- a. Farmer 1 (husband): “We don't have anyone here to raise a buffalo...” Farmer 2 (wife):
“We have become old now, we don't have much energy but we do our best.”
- b. Man farmer: “Now the family is small, but before we had two buffaloes. Recently too, but we had to sell them. It's because of family problems.”

Two other farmers reported that money was a major constraint alongside labor; one explained, “In this village, if you look around, some people with money have one or two buffaloes... [here] there's no money for a buffalo. Even more so than money we don't have manpower.”

Some farmers who have reduced their buffalo herds replace them with smaller livestock that require less ongoing labor or a shorter duration of labor investment. Eight farmers described their new practice of purchasing buffalo calves, bulking them up and selling them within 6-12 months. For families with fewer members, farmers who work off-farm or who may split time between a village home and a town or city home, this arrangement is more flexible and requires less work. Goats and sheep are also a common option; almost all (n=18) households keep some, and the three households that have no large livestock still choose to keep some small ruminants. They are seen as a quicker form of income, requiring less work than larger animals (though still significant labor investment in grazing and/or fodder collection). When asked about swapping buffaloes for goats, one farmer with a large goat herd explained, “People were too few... That's the reason. [With goats, the income is] ok, because it's quick. Raising buffalo takes a long time even though the profit is good.” While these shifts from larger to smaller livestock are a useful

adaptation to labor scarcity, they result in less manure available for FYM production in these households.

Keeping and adding livestock

Despite these barriers, livestock husbandry is alive and well in this community. All interviewed respondents kept some livestock (at minimum, 2 goats), and several farmers (n=4) reported adding more buffalo in recent years. Farmers are motivated to keep livestock because of income-producing opportunities from livestock products and their need for FYM to fertilize crops, and some are assisted by new feed strategies that reduce labor requirements. Many of the farmers (n=12) gain income from marketing livestock products, including dairy (n=4), buffalo for meat (n=8) or goats and sheep. All farmers who choose to raise buffalo calves reported that a major motivation is the quick income from sale of the animals, especially as the market for buffalo meat is rising. The community-level reduction in adult buffalo herds is also increasing the local demand for dairy products, creating additional market opportunities for those who choose to rear them.

A number of respondents (n=6) also specifically referenced manure production for fertility in cropping systems as an important reason to sustain livestock numbers. One woman farmer explained, “We have to raise livestock for manure... No, it won't [work otherwise].” Manure production is a key reason for farmers to regularly raise buffalo calves (rather than eliminating buffalo entirely) and add more adult buffalo to their flock. One farmer reported that she had sold off her buffalo several years ago but added it back to fulfill manure requirements. Only one farmer, the sole commercial dairy producer in the interview pool (keeping 15 buffalo) reported that he has sold FYM for income, but only infrequently and in certain circumstances; in most years he finds it too valuable for his own crops. Summing up the triple-pronged reasoning

for continuing to raise buffalo, a young farmer remarked: “By selling milk, it can be the source of income. Plus, compared to oxen, buffaloes produce a lot of manure... Then, if they have calves, we can sell them and make money.”

For many farmers, especially women farmers, the work of collecting fodder for their animals is the most time-consuming livestock-related activity, and several respondents explained that new strategies for efficiency in this area allowed them to maintain or expand their herds. Three farmers reported that planting fodder grasses near to their homes has had a major impact on the ease of livestock care compared to the traditional method of foraging for fodder in jungle and field borders. One of these farmers received fodder plants through a government program, and another (the commercial dairyman mentioned above) made significant investments in planting out a whole field of fodder grasses to feed his large herd. Another farmer explained that irrigation access is essential here, saying “the main thing for livestock is irrigation. If there is irrigation, we can plant fodder grass.” Many farmers (n=10) have made investments in cement feed troughs and fodder cutting machines or other shed-based processes which improve the ease and efficiency of feeding. Although these strategies have tradeoffs (see “shed improvement” below), they reduce the drudgery of small-scale livestock production. One farmer explains how this reduces drudgery:

“Compared to before, it is easier now. Before, it was very painful work. Even when we were kids, we used to take grass from the forest for fodder. There was no practice of planting fodder grasses. We used to bring a lot of fodder, and they would eat a small portion of it, maybe half. What has happened now? The shed has been improved. Improved fodder species have been planted... Now we use a

machine to cut the fodder, so they don't need very much, just a little. We also feed them some *kudo* [grain porridge].”

Through these labor-saving adaptations, some farmers are able to maintain or even grow their livestock herds.

Mechanization and oxen

Because oxen are used primarily as draft animals for tillage and field operations, decision making about oxen is somewhat distinct from that for other types of livestock; as many shift towards mechanized tillage and field operations, farmers (n=8) are keeping fewer oxen than they did in the past. Among the interviewed farmers, mechanization is common: 14 farmers report doing their tillage with a walk-behind mini-tiller. Ten farmers use their own oxen for tillage and among those, five farmers use both oxen and tractor.

Farmers' reasons for transition from oxen to mechanized traction include labor and practical considerations. Tractor-based fieldwork is regarded by some (n=6) farmers to be easier than ox-driven implements. Some said it requires less labor or is less expensive, that it is faster or more convenient, or that they don't have anyone at home who knows how to drive the ox team anymore. One older man farmer reported that labor scarcity has driven people in his village to abandon oxen: “Here we have shortage of people. 16 years ago we had buffalo, oxen... But usually there aren't oxen now. People have left them.” Another, a younger man farmer, explained that the traditional skills have been lost: “The number of oxen is less than before.... Because the mini-tillers are used to plow the field. Even if I keep the oxen I can't really plow [with them]. My father, just a few people around can. So, we have to use machines.” Another farmer added that tractors are simply easier; “The business of raising oxen is now avoided by everyone. Now, machines have come and it's faster.” It is important to note that most of the

tillage is done by men (only one woman reported operating the tractor sometimes), and most women farmers in the group rely on male relatives, neighbors or hired help.

There are a number of practical and traditional reasons for continued use of ox-power, which nearly half of farmers (n=10) do, though many not exclusively. Some farmers, especially those with marginal or upland fields (n=3) utilize oxen-driven implements because they are preferable for smaller, rocky or hilly plots. There are also several specific field operations that farmers prefer to run with traditional implements (field leveling, maize sowing, post-emergence cultivation in maize). One farmer reported that it was unaffordable to hire a tractor, so they kept their oxen. Another kept both oxen and a mini-tiller for redundancy, having found the machine unreliable. Manure is also a consideration; although some farmers (n=2) explained that oxen produce less manure than buffalo, another quoted manure as an additional reason to keep their ox team.

B. Livestock shed structure and process

Despite widespread reductions in livestock, many farmers have invested in improvements to their livestock shed structures, with related implications for FYM management. More than half of the interviewed farms (n=11) have improved shed structures, which include at minimum a cement floor and tin roof, compared to 10 who have not made these improvements. Most (n=10) of the improved sheds also include feed upgrades with a cement trough and hand- or motor-powered fodder cutting machine. Especially in synergy with fodder plantation in the vicinity of the homestead, these modifications greatly improve the efficiency of the feed process and reduce labor investment: farmers use the machine to mix and cut the fresh fodder with straw or other bulking material, creating a nutrient-dense ration that is easily fed in the cement trough and consumed nearly in its entirety by the animals. This contrasts with the traditional practice of

placing large cuts of mixed rations on the ground or in an improvised feeder, which results in significant loss and feed refuse.

The cost of these investments is not insignificant, and yet farmers prioritize them for a number of reasons beyond feed efficiency improvements: some farmers were persuaded to the importance of shed improvements through municipal livestock office outreach programs, other farmers built cement floors for ease of manure removal, and others appreciated the durability of the structures (and future labor savings in repair work). Two of the farmers received a subsidy through government programs to purchase supplies and complete the construction. Nine of the farmers self-funded, some (n=4) of those reporting significant challenges in their attempts to secure government subsidies for the project. The farmers with the most advanced shed systems are often located among a number of households who have made the same upgrades; this is knowledge that seemed to travel through neighbor networks. Several farmers (n=4) who had not made shed improvements remarked about their humble livestock structures, with two self-consciously explaining that their shed is “not really a shed.” These farmers listed shed improvement as high priorities, but noted financial, time and labor barriers.

Although they have benefits for feed efficiency and animal welfare, these structural improvements to livestock sheds also impact FYM quantity and quality, especially when linked to reduced access to forest products for livestock bedding and fodder. Six farmers with improved sheds explained that the new processes result in less organic material added to the FYM pile, because cement floors reduce the need for bedding (traditionally abundant leaves from the forest) and/or because the fodder improvements reduce leftover material. One woman farmer explained: “Back then, we used to bring fodder and leaves from the jungle... which would result in more FYM. Nowadays we... don’t feed the jungle fodder but only grass by cutting it with the

machine.... Now there is only animal dung to be thrown in the pile.” Beyond these shed-related causes, farmers (n=5) report that their access to the jungle has reduced in recent years; restrictions imposed by the local community forest management groups prohibit access during certain times of the year (opening only in winter), or the whole year. Some go to the forest anyway to collect these important resources, as one woman farmer explained, “I go outside the rules sometimes but it feels like stealing.” The work of collecting bedding and fodder has traditionally been an onerous and time-consuming task, especially for women, and women farmers report reductions in forest visits due to scarcity of labor (n=3) or fear (n=2). One farmer said she had fallen and been injured in the forest in the past, so “that's why I'm scared to go to the forest. If I break an arm or a leg, what will I do?” A number of farmers (n=4) report that the reduction in feed and bedding residues has decreased the quantity of FYM available, and farmers are uncertain about the impacts on FYM quality, with different opinions about FYM composed solely of manure. A woman farmer sums up her mixed feelings about these changes: Now that she doesn't need to go to the jungle, “life is easier now, but the FYM would be better if we added jungle leaves... there would be more.”

C. FYM Management

Current practices

The best practices for FYM storage and management are adopted by farmers at low rates (Fig. 3). Similar to the surveyed farmers, less than half of interviewed farmers (48%) store their FYM in a pit or partial pit. Even fewer (10%) cover their stored FYM or turn their FYM (29%). Among interviewed farmers, no farmers have adopted all three best storage practices. Around 24% of interviewed farmers have channels in the shed floor for collecting livestock urine, though not all of them utilize this resource.

Although most of the farmers are not aware of the potential for nutrient loss in the FYM storage process, some choose FYM management upgrades for practical reasons and FYM quality improvement. Of the ten farmers who have an FYM pit, three farmers built it to improve the quality (full decomposition) of their FYM, and two did so because it was easier to collect manure. Not all the farmers purpose-built pits for FYM storage; one farmer repurposed an old cement tank and another built a small fence of sticks to contain and protect their FYM pile. Three farmers remarked that even a centralized storage pile (no pit) is an improvement from past FYM storage practices, as they used to just keep small piles of manure around the farmyard or “throw it in a field” nearby.

Covering practices, though uncommon, are done for manure quality and ease of management. Two farmers covered their pile with leaves/organic materials: one to keep rain from filling their pit, the other to keep the manure from drying out. Two other farmers placed their FYM storage under a shade tree to protect from sun/drying. Of interviewed farmers who turn their FYM (n=6), four turn the FYM specifically to aid in the composting process, whereas two turn the FYM in the process of emptying their pit when it fills up. Another three farmers did not turn their pile, but they used a more traditional practice of retaining manure and bedding on the shed floor for a month or more, where it pre-composts in place and then it is turned/mixed when removed (often at the end of the winter). Of the five farmers who had structures for collecting livestock urine, only three actually used it on their crop fields, diluted with water; two others built the urine collection system as a part of shed improvements but didn’t understand how to use the urine. Although not part of the specified best practices, four farmers have an additional practice of adding water to their FYM pile periodically during the dry season to encourage composting. One woman farmer explained how on-demand water access has

improved her FYM quality, saying “Sometimes if it doesn’t rain, the FYM doesn’t decompose. Now we have a tap, we can add water from the tap. Before, we had less water availability, so it was problematic.”

FYM knowledge trends and other barriers

Compared to shed and field application improvements, farmers are largely unaware of recommended best practices for FYM management. Farmers’ knowledge about FYM management comes mostly from tradition and family (n=7) and many farmers (n=6) report doing this exactly the way their parents did. The process is considered elementary, with no need for improvement; when asked about her FYM management process, one woman farmer, laughing, explained: “We don’t do anything extra. We just feed grass to the buffalo, they make manure and we sweep it and throw it into the pit. It’s just that.” Only seven farmers have some knowledge about the possibility of nutrient loss in FYM storage, six of them from some exchange with municipal or other agricultural extension services. Five farmers have been exposed to new strategies by visiting or observing farms in neighboring or far-away parts of the country. Two farmers reported that “long ago” there had been an NGO-driven project in the area that helped farmers build structures to protect their FYM storage, but when the organization left (due to political violence in the early 2000’s) farmers did not maintain the upgrades “because of the other work they need to do.” Compared to shed improvement, farmers (n=6) say FYM storage improvement is not a priority. When asked about covering the pile, one farmer explained, “Even if we understand it, the farmers can’t do it. They don’t really want to.” Another, when asked what she would do if money was not a barrier, a farmer (with no FYM upgrades) responded, “I will improve the shed. About manure storage, there’s nothing we need.”

Beyond the knowledge gaps, farmers faced a number of labor and finance barriers to implementing these FYM improvements. The most common (n=7) was lack of available labor to make the improvements or change to the current process. One older farmer didn't have the energy to do all the tasks needed to construct a roof for their manure storage, saying, "I don't have the strength. You have to cut wood, dig up, bury it and create the support. It takes tedious work." Three farmers explained that they do have enough labor to complete the current tasks, but not to add more, and one woman head of household said she was already deeply overwhelmed and couldn't imagine adding anything else. Financial limitations are also a factor for five farmers, with two of those saying that they had experienced significant life expenses recently including children's education, emergency health expenses, a death in the family, and repayment of debts from migration which make it difficult to invest in additional projects.

Some farmers also see practical downsides to the recommended improvements, including pit storage of FYM: it may be harder to remove FYM from a pit when complete (n=3); they're concerned the FYM will become waterlogged as the pit fills with water (n=2); one perceived that using a cement pit will keep earthworms from assisting in decomposition; and one farmer had a buffalo fall into a manure pit and become injured, so she filled it in. For covering the pile, there is a perception that this will encourage it to dry out, slowing the composting process.

Although most farmers do not have any plans to improve their FYM management practices, two farmers (the most commercialized) were in the process of building a roof and improved urine collection systems with canals to mix with water and apply urine directly to the fields. One, the commercial buffalo farmer, would like to improve his process for selling FYM to other farmers nearby, but is limited by lack of funds.

D. Field application

FYM and inorganic fertilizers

The final phase of the FYM management process occurs in the crop field: here, farmers decide how much FYM to apply on which crops compared to other fertilizer options, how to transport and when to apply and incorporate FYM. All of the farmers use FYM, with five stating that FYM is essential for achieving yields and maintaining soil health. One farmer who has made many other technological upgrades explained why he still invests heavily in FYM by simply gesturing to a healthy maize field and saying: “Why do I keep using manure?... This has manure in it.” At the same time, most interviewed farmers (n=17) reported that the quantity of FYM available has decreased, both due to reductions in livestock (n=13) and reductions in non-manure organic materials in the FYM (n=6). Due to shrinking availability, farmers were often spreading smaller quantities of FYM over the same amount of land, or found that they did not have enough FYM to apply to all the fields they would like to (n=8). Four farmers reported that their yields were less than they used to be, with one older woman farmer pondering, “We used to have plenty of manure as we had been using more bedding materials.... and, we used to have good harvests. Now, production is less and we wonder why this is happening.” One farming couple remarked that while their yields are less, the household is smaller, too, so it’s not a big problem for them.

Farmers adapt to FYM availability gaps by altering their FYM production or application strategies and by integrating or substituting FYM with inorganic fertilizers. Some farmers have begun rotating FYM applications seasonally or annually, not applying to each planting. Other farmers (n=4) reported that they bulk up their FYM by adding more (not less, as seen above) organic materials like dry leaves to the pile; others use less decomposed FYM to meet their needs. Most of the farmers (n=18) integrate FYM with purchased inorganic fertilizers. Farmers

reported a number of barriers to inorganic fertilizer access: three said they believe it is harmful – “people say it will kill the soil” – one said it was bad for human health; one said the inputs are too expensive; and two said that they lacked knowledge about how to apply inorganic fertilizers. One farmer explained how the recent pandemic spurred her family to begin purchasing fertilizer: “We don't add a lot, and we didn't use it before. We made rice paddies when more family members were home during Corona. At that time, we started adding a little urea, but we don't even know how to use it just because we used to use only manure.” In this case, labor dynamics determined crop decision-making (shifting to rice), which in turn shaped fertilizer usage. Now that the pandemic is over, the household is small again, but the rice fields remain, and with it the practice of applying urea – despite insufficient information.

As this quote demonstrates, decisions about which fertilizers to apply are related to each farmer's cropping choices. Like surveyed farmers, those interviewed applied more inorganic fertilizer to rice than maize (Fig. 4). For rice, 78% apply FYM, while 94% apply inorganic fertilizer (urea and/or DAP). For maize, FYM is more important than inorganic fertilizer: 100% of interviewees apply FYM, while only 44% apply inorganic fertilizer. When asked why they apply inorganic fertilizer to rice, farmers said that rice won't produce well otherwise; urea makes rice “black” (dark green) and yield well. One woman farmer explained: “In maize, it will produce well even without adding fertilizer. But not rice.” The choice is also practical for some: rice is planted after maize, so FYM stocks have been depleted by that time. It is labor-related for others, as many rice paddies are far from home and take more work to carry FYM. On the other hand, FYM is deemed essential for maize, which is often planted on upland or hilly plots; some say maize “won't produce otherwise” and others see FYM as less powerful than inorganic fertilizer and maize as a less demanding (and less essential) crop, so FYM is “good enough.” In

the interviewed group, more farmers (n=3) reported transitioning land from maize to rice recently (due to short-term labor availability, new irrigation availability, and monkey problems in maize), with only one transitioning rice to maize (due to scarcity of labor to plant rice).

FYM transport and incorporation timing

Compared to FYM storage improvements, farmers have more awareness about reducing the gap between FYM application and incorporation into soil to limit nutrient loss. Seven farmers make conscious efforts to incorporate FYM quickly: three within 24 hours of application and four within 1-2 days. Many have learned this practice from their neighbors. One woman farmer explained the downsides of the old methods: “Before, how it was, we would carry manure in Chait, Baisakh (March, April). Sometimes the ox drawn tiller wouldn’t work. If it rained, the fertilizer would leach off, and the gases would evaporate.” Of the five farmers who still leave FYM on the surface for more than 2 days (sometimes much longer, up to a month), some reported that they are following traditional practices, they struggle to find tillage equipment on time, or their shared irrigation source (needed to incorporate FYM) is unreliable. Three farmers said that labor is a major reason for delayed FYM incorporation. The process of carrying FYM from the homestead to the field is one of the most labor-intensive aspects of the entire process, yet only two farmers have ever used machinery to transport FYM; the rest rely on household labor, hire laborers (n=5), or utilize the traditional system of *parma laune*, reciprocal community labor. One farmer explained the process: “If you have people from 8-10 houses, you have 8 people, you carry for one house today, for one tomorrow, for one the day after tomorrow.” Although this shared labor system is key to achieving labor-intensive tasks on many of these farms, farmers (n=2) reported that it also poses a challenge for achieving their timing goals. The women interviewed were more likely to mention these labor challenges.

Other key themes

Labor, migration dynamics and gender

For these farming households, out-migration is a powerful force with impacts on labor availability and gender roles that in turn shape agricultural decision making including FYM management. In the interviewed group, 78% of responding households have family members who have migrated outside the village (2 in Nepal only; 7 in both Nepal and abroad; and 5 abroad only). Families send members abroad for opportunity and income, including to purchase food required to overcome on-farm yield declines. One woman farmer explained: “There’s no money. There’s also no grain for us to eat at home. We need more money, so they go to work abroad.” Among the interviewees, six specifically noted that migration has resulted in labor scarcity that impacts farm functions. Some farmers say migration is worth the trade-offs, while others (n=3) say the costs of migration are too high, for example it has led some into debt that now limits their capabilities. Two male farmers said they went abroad and did not like it and decided to come home and try to make a living on the farm; these two have invested a great deal in livestock and FYM improvements. However, both of those farmers are considering leaving again or sending their children abroad because of financial pressure, including medical, education and farm expenses. Some farmers (n=2) also relocate from the village to nearby cities, buying or renting an urban home while maintaining the farm part-time; this sometimes results in reduced investments, including fewer livestock, on the farmstead.

Although much of the farm work and some of the decision making across the interviewed households were done by women, only 3 of the interviewed farms were headed by women, all because their husbands and or/sons had migrated abroad. These women spoke to particular challenges that they face. Because tillage is traditionally men’s work, two of the women reported that their field operations and timing were impacted because they need to hire in a man from

outside the household; only one woman said that she sometimes drives the ox-driven plough herself. This same woman explained that in both the traditional *parma laune* shared labor system and in the rural wage labor system, women's work is valued at half of men's, so solo women are at a significant disadvantage in both. Finally, two of the women had no formal education, although their brothers had been sent to school. This has made certain aspects of farm management more difficult for them. Still, they say a lot has changed since they were young; nowadays they prioritize education for all their children. One elder, a grandmother, explained the difference, saying, "I can't go that far up, but my children can. It's like that." This ambition also means younger generations – girls and boys alike – may leave the farm to seek opportunity beyond.

Generational changes and attachment to agriculture

In the midst of these transitions, farmers spoke to generational differences in preferences and priorities that also impact agricultural decision-making, including around FYM. Families with several generations living at home are often able to divide labor to manage all the tasks associated with livestock production; one young male farmer explained that he has recently added more buffalo to his herd, but when fewer family members were on the farm, "we couldn't do it. We didn't have anything; we were very busy. Now, with my father sometimes at home, he plants fodder grass. Now there is a buffalo, also a goat... It's my daughter's school break, we should also teach her a little of this work." On the other hand, farmers (n=4) explained that the younger generation is not as interested in agriculture, and if they are, they often don't prioritize livestock. At the same time, older farmers are not able to continue bearing the bulk of the work as they age. One older woman farmer said: "I don't have energy. My grandchildren are just focused on foreign employment, they don't do anything here at home. Nowadays, these children

don't go for fodder and leaves in the jungle. They are just focused on their mobile phones. I wish they would cut grass and do work around the farm like us.” One farmer explained that younger folks see farming as too difficult: “Why do the hard work of farming” when you can work to buy food instead? An older farmer expressed fatalistic uncertainty when asked about the future of agriculture in his village, saying simply: “what will be, will be, it seems.” However, it’s clear that some farmers are still deeply attached to the lifestyle of farming and rural life; one man who has made significant investments in livestock loves the freedom of it: “I think agriculture is the best occupation... We can be at home and do it on our own. There’s no fear that someone would rule us, scold us... We just have to buy salt and other things from the bazaar, but otherwise we just grow it all at home and eat.” He sees livestock and FYM as crucial components of his farm’s self-sufficiency.

Farmer visions and needs

When asked what support they need to implement improvements in livestock and FYM, many farmers (n=9) expressed desire for increased government support for farmers through subsidies and programs. Farmers would like to access subsidies specifically for the purchase of buffaloes, fodder cutting machines, and materials to improve sheds and build protected FYM storage. Two farmers requested improved training and extension programs about FYM management, as they recognized knowledge gaps around nutrient loss and FYM storage. Others (n=3) suggested additional support for dairy sales and marketing, as they face significant challenges in milk sales, including market saturation, late payment, and difficulty accessing buyers. Farmers highlighted resource gaps that could be filled through government or other support, including improved irrigation infrastructure (n=3), fodder planting (n=2), and water retention ponds (n=1). Farmers also emphasized that the government subsidy programs and

processes need reform; four farmers have faced significant challenges accessing funding. These include difficulties registering their farm, insufficient available funds, mistakes in subsidy calculation, and late payments. Three farmers, all women heads of household, expressed hopelessness about ever receiving help from the government, because only people with connections and clout do. When asked what she needed from the government, one of these women replied simply, “what does it matter if I need it, the government won't give me anything... I'm just a poor woman.”

3.3 FYM Practices and key drivers

Small farmers in Gurbhakot Municipality have a diversity of experiences and describe a variety of FYM management practices, but across the farms several dynamics were widespread (Table 3). A core limiting factor is the quantity of FYM available, largely due to reductions in large livestock like dairy buffaloes and oxen. Labor scarcity, fodder scarcity, and transitioning to mechanized tillage are major reasons for decreased large livestock, while livestock market opportunities, farmer prioritization of FYM, and livestock feed improvements encourage farmers to keep livestock. A majority of interviewed farmers have made improvements to their livestock sheds, which reduce the labor required for animal care and save labor in manure collection. At the same time, the improvements result in reductions to the quantity of bedding and feed refuse added to the FYM, thus diminishing the total FYM quantity and impacting quality. This dynamic is amplified by reduced access to jungle resources. Few farmers have made investments in FYM storage improvements (pit, covering, and turning) because of knowledge gaps and labor scarcity. In the field, farmers have made great strides in the efficiency of FYM application, with many reporting that they are making new efforts to reduce FYM nutrient loss through quick incorporation. Access to irrigation and mechanization facilitate this transition, while labor

challenges are a key barrier. Many farmers are adapting to diminishing FYM availability by incorporating inorganic fertilizers with FYM, but lack of information about appropriate application rates are a major barrier to efficiency and effectiveness.

3.4 Livelihood capitals and FYM management

In 21 semi-structured interviews, farmers shared detailed perspectives on the barriers and opportunities that shape their FYM management practices (Table 3). To organize the complexity of their narratives, I draw on the Sustainable Livelihoods Framework (SLF), developed by Chambers and Conway (1992), Scoones (1998), and DFID (2000) (Figure 5). The SLF models the systemic and local factors that facilitate sustainable rural livelihoods “which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation” (Chambers & Conway, 1992, p.6). Key to the SLF are “livelihood resources” or “capitals” that build resilience and make sustainable livelihood strategies possible.

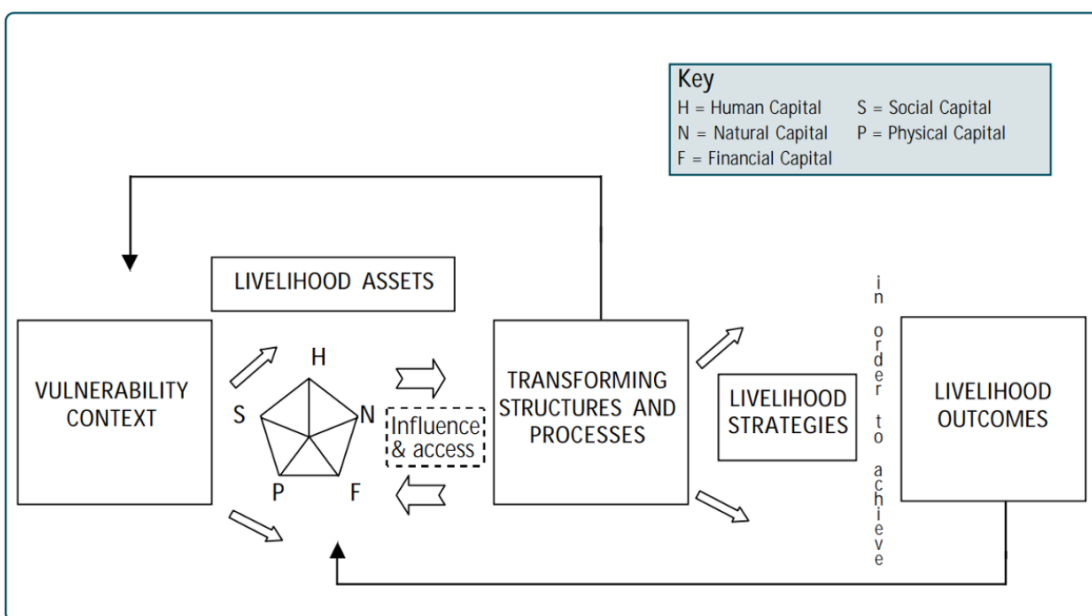


Figure 5. The Sustainable Livelihoods Framework (DFID, 2000)

In this study, I understand the barriers and opportunities reported by farmers to signal the presence or absence of these livelihood capitals. Each barrier or opportunity is linked to a primary type of capital that emerged from the farmers' responses: human (divided here into knowledge and labor), financial, natural, and physical. These capitals shape farmer capacity and decision-making across all four key FYM processes. The number of instances farmers mentioned barriers and opportunities, and the associated capitals, are presented in Figure 6 and summarized in Figure 7. These findings indicate that the most impactful drivers are associated with the human capitals of knowledge (27% of barriers and 50% of opportunities) and labor (20% of barriers, 0% of opportunities). The other capitals are reported fewer times but are still important to the farmers: financial (10% of barriers, 14% of opportunities), physical (22% of barriers, 26% of opportunities) and natural (17% of barriers, 10% of opportunities). As identified in the literature (Bebbington, 1999; Van Dijk, 2011) and by the farmers themselves, it is important to recognize that access to all of these assets can be facilitated through social capital.

Human Capital: Knowledge

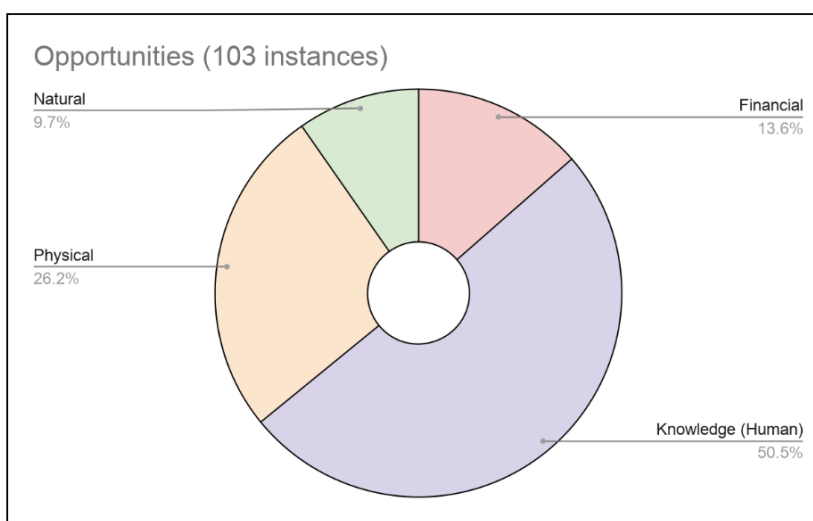
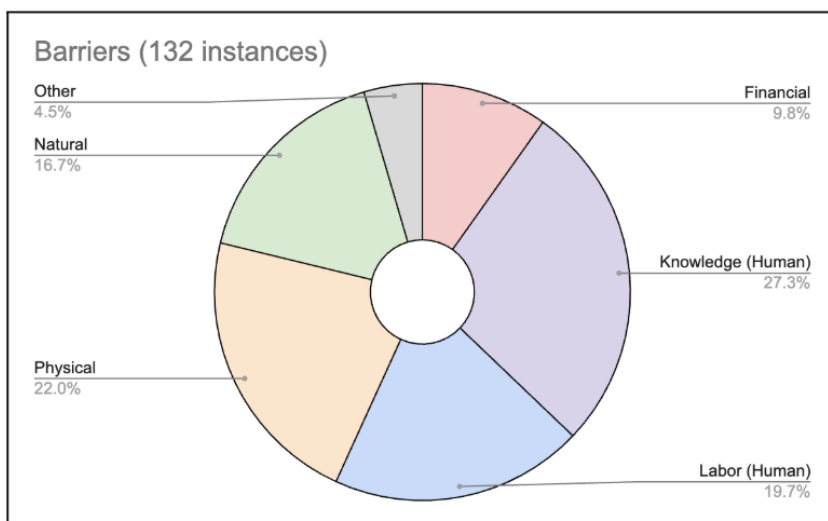
Farmer knowledge dynamics are at the root of many improvements to FYM sheds, storage and application efficiencies. Some prior research shows that access to the right kinds of information through effective channels is key for adoption of sustainable practices like FYM (Aryal et al., 2021; Dhakal & Escalante, 2022). Farmers' awareness and prioritization of best FYM practices are shaped by knowledge that they receive through tradition and family, external sources (extension, training and observation outside the village) and local networks (neighbors, cooperatives and farmer groups). Traditional knowledge about the importance of FYM is widely available among the farmers, and is a major motivator for some farmers to sustain or expand

Figure 6: Livelihood capitals associated with the opportunities and barriers. Representation of drivers and barriers for FYM dynamics according to interviewed farmers (n=21), color coded by type of livelihood capital (financial, knowledge, labor, physical, or natural). Pie charts depict the number of instances barriers and opportunities associated with each capital were mentioned in interviews or experienced by farmers. Bar graphs represent the number of farmers reporting each opportunity or barrier.

Legend	
Financial	
Knowledge (Human)	
Labor (Human)	
Physical	
Natural	
Other	

FYM dynamic	Opportunities for increase/adoption	Number of farmers	Barriers to increase/adoption	Number of farmers
Decrease in large livestock	Market for milk, meat (12)		Mechanization of tillage (14)	
	Desire for manure (6)		Labor scarcity (10)	
	Oxen traction - steep fields, specialized operations (4)		Fodder scarcity (8)	
	Fodder planting (2)		Money scarcity (2)	
Improved sheds	Farmer prioritization (11)		Challenges with subsidy program (4)	
	Community knowledge sharing (4)		Labor scarcity (2)	
	GoN outreach and subsidy (2)		Money scarcity (2)	
Non-manure inputs in FYM	Forest access (4)		Improved shed and fodder management (6)	
	Desire to increase FYM quantity (4)		Reduced forest access (5)	
			Labor challenges (3)	
Improved FYM storage	Knowledge of nutrient loss (extension/training) (7)		Knowledge gaps (nutrient loss in storage) (14)	
	Knowledge of improved FYM storage practices (neighbors/travel) (5)		Labor scarcity (7)	
	Desire for fully composed manure (turning) (4)		Practical challenges (6)	
			De-prioritization (6)	
			Money scarcity (5)	
Field application: FYM quantity applied	Farmers think FYM is essential (5)		Decrease in large livestock (13)	

	Sustained/increased large livestock (5)		Less organic materials in FYM (7)	
	More organic matter added to FYM (4)			
Efficient timing of FYM application/incorporation	Farmer knowledge of nutrient loss in field (neighbor networks, extension) (7)		Lack of labor (4)	
	Easy access to tillage equipment (3)		Unreliable irrigation access (2)	
	Access to tractor to carry FYM (2)		Using traditional methods (2)	
Integration of FYM and inorganic fertilizers	Access to inorganic fertilizers (17)		Belief that chemicals are harmful (3)	
			Transition maize to rice (less/no FYM applied) (3)	
			No FYM available (2)	
			Knowledge gap - inorganic fertilizers (2)	



livestock production. On the other hand, the most powerful barriers to achievement of the best FYM practices (pit storage, covering) are knowledge gaps about the potential for nutrient loss in FYM storage, with this barrier being one of the most reported among farmers (Figure 5). This information is not part of the traditional FYM knowledge system, and most farmers have not received it through extension or training services. The spread of new knowledge around the community is also important: most of the farmers have learned through neighbor networks to prioritize shed improvements and quickly incorporate FYM once applied to the field.

Human Capital: Labor

Even when farmers are aware of the best FYM practices, labor scarcity is a powerful barrier to achieving those standards, making up 20% of the reported barriers across the four FYM processes. Labor was the only capital associated with all barriers and no opportunities (Figure 5). This finding aligns existing literature finding that labor scarcity limits agricultural production throughout Nepal (Maharjan et al., 2013; Pant, 2013). Here, labor scarcity limits livestock populations, non-manure contributions to FYM (due to decreased resource gathering from the jungle), and effective timing of FYM application and incorporation. Even farmers that utilize shared community labor or hire workers face constraints to the ideal timing of operations and accept trade-offs that reduce FYM efficiency. Out-migration (both regional and international) is a key constraint, as it reduces household labor availability and impacts gendered labor distribution. Although some literature (Kandel et al., 2026) finds that the additional financial resources provided by out-migration may increase farm capacity, no farmers in this study reported this; instead, many spend the extra funds on non-farm expenses like children's education or medical costs, while others find themselves in migration-induced debt. Larger

households with fewer out-migrants, especially intergenerational households with older members (more likely to support traditional livestock systems) living alongside younger members (providing needed strength and labor), were more likely to achieve FYM best practices.

Other capitals: Financial, physical, and natural

Access to financial, physical and natural capitals also fundamentally shapes farmers' capacity to implement FYM improvements. The ability to produce income from livestock by selling milk or meat increases the likelihood of sustaining or growing livestock herds, and thus producing more manure. Farmers with limited financial resources often de-prioritize livestock, shed improvements, and FYM storage upgrades. Meanwhile, the two farmers with the greatest investments in livestock and FYM successfully attained subsidies and loans that allowed them to take these risks. Physical resources, including quality and location of land holdings and access to irrigation infrastructure, are important here as well. Farmers dependent on more marginal (steep, rocky) fields are more likely to maintain oxen for traction (providing a source of manure) and plant maize, which leads farmers to prioritize FYM over inorganic fertilizers. Irrigation access allows farmers to plant fodder crops and time their FYM incorporation more precisely, but it also encourages some farmers to transition to rice, which (many farmers believe) requires less FYM. Access to community forests allows farmers to acquire natural resources such as fodder and bedding, which supports livestock adoption and increases the quantity of FYM.

Social capital and network effects

Although each of the above capitals directly contributes to farmers' FYM management, social capital emerged as a fundamental enabler. Access to these capitals is facilitated through community networks, which are themselves shaped by intersectional social factors such as gender, caste, age, education, location and socioeconomic status (Tavener & Crane, 2019; Tran

et al., 2022). Within the SLF, this is called the vulnerability context (DFID, 2000). In their recent re-formulation of the Sustainable Livelihoods Framework, Natarajan et al. (2022) emphasize that sustainable livelihoods are fundamentally relational, and the capitals exist within structures of power and influence. Our research supports this concept, highlighting ways that structural factors can build or diminish social capital and other capitals, thus impacting FYM management.

For example, while most farmers have access to traditional knowledge about livestock and FYM through their families, other forms of knowledge are less evenly distributed. In this group, certain farmers (often male, more mobile, more commercial farmers) are more likely to access training and extension services; these farmers are more likely to be exposed to knowledge about improved FYM management strategies and particulars of fertilizer application. Meanwhile, farmers adopting certain practices including shed improvement, timely FYM incorporation, and keeping dairy buffalo, seem to cluster together, as neighbors share information with each other. Farmers with stronger and more informed neighbor networks seem more likely to make FYM improvements than those without. Labor availability is also impacted by social capital. Many FYM tasks are done by household members and thus are tied to household size, while other high-labor tasks (like carrying FYM) rely on a strong local network or access to hired labor to provide shared labor contributions. Access to financial resources – markets, credit, subsidies, and capital – is tied to socioeconomic status and relationships with institutions, including banks, cooperatives, and municipal extension services. Male farmers were more likely to have access to these resources.

The three farmers with the least FYM improvements were women heads of household; gender is a key factor here, but it intersects with other marginalizing features that impact access to livelihood capitals. Each of these women farmers has very small families, and their close men

relatives (husband, father-in-law) are living abroad or have passed away. They all reported significant financial hardship and had not accessed any farm training, extension services or subsidies. Two of these women also belong to lower caste groups. A number of studies have found that out-migration of male relatives from Nepali families leads to increased women farmer empowerment and adoption of sustainable agricultural practices, but this is the case only when remittances are significant and in her control (Maharjan et al., 2012; Gartaula et al., 2010; Kandel et al., 2026). The women farmers in this study seem to face multiple dimensions of marginalization, lacking the capital (knowledge, labor, financial) needed to overcome the loss of male household members. Here, too, social capital is key; this finding aligns with research that community connection through farmers groups, cooperatives and other public spaces is an important enabler of female farmer power (Spangler & Christie, 2019; Kandel et al., 2026).

3.5 Opportunities and future paths

Prior research has effectively used the Sustainable Livelihoods Framework to locate entry points to support farmers in adopting sustainable practices (Suleman & Osumanu, 2026; Martinez-Baron et al., 2024; Tong et al., 2023). By identifying the particular capitals that create the greatest barriers and opportunities for FYM improvement researchers and extensionists can focus on supporting farmers to build those capitals. My research also finds that social capital is a key facilitator for the others, so it is essential to attend to structural factors like gender, poverty and education as well as network factors like social connection. Depending on their structural positioning, farmers need targeted assistance to improve their FYM management, and marginalized groups should be prioritized.

To understand how these dynamics impact the interviewed farmers, it is useful to sort the farmers into groups according to their intersectional household characteristics, access to key

capitals, and adoption of FYM best practices (Table 4). They settle into five generalized categories; not all included farms align on all metrics, but they are similar enough to group together for the purpose of describing barriers to FYM improvement and identifying opportunities for action:

1. *Small women-headed households* (n=3) have extremely limited labor, financial resources and extension access; they have few or no large livestock and little FYM to manage.
2. *Low-resource mixed households* (n=5) are also limited financially but have multiple adults (often a married couple or a woman and in-laws) present. They have marginally more labor available, often have some large livestock but are usually unable to make investments in shed or FYM improvements.
3. *Aging households* (n=4) are composed of an elder husband and wife whose children have established households elsewhere or are working abroad. Some of them possess above average financial resources. Their access to labor is extremely limited and although they often value livestock and FYM highly, their energy to maintain herds is often insufficient.
4. *Multi-generational households* (n=6) have more members and possess more resources, knowledge and labor capital, often with at least one family member working outside the home providing income. These households have made investments in shed improvements and some FYM improvements, and often have some contact with extension services. Many are making some income from their livestock, with some transitioning from oxen to buffalo, or dairy buffalo to meat buffalo.
5. *Small commercial farmers* (n=3) are entrepreneurs (men) who have somewhat more access to financial resources (subsidies/loans) and relationships with extension services.

Their household labor is variable, but they may hire laborers. They have made notable investments in increasing livestock and making shed improvements and are producing a significant portion of their household income through livestock-related activities.

With these farmer types in mind, knowledge capital can be built by reinforcing existing traditional knowledge that values FYM, by leveraging community networks to spread information, investing in inclusive farmers' groups and cooperatives, and by targeting extension services towards the particular needs of less-served populations like women farmers.

New biophysical research is also needed in the local context to quantify the effectiveness of the specific FYM improvement practices and make that data available and relevant to farmers. In FYM improvement, labor capital is a particular challenge because traditional FYM practices are labor-intensive. Investments can be made in labor-saving technologies like improved sheds and mini-tillers; however, farmers should be made aware of the trade-offs for FYM quantity. For building physical and natural capital, key areas of investment are in fodder production, irrigation infrastructure, and jungle resource access. Access to affordable fertilizers is needed and must be coupled with targeted information about specific application strategies, especially in integrated management with FYM. Additional support for marketing of livestock products, including dairy, is also essential to support growing financial capital that allows farmers to maintain livestock.

Despite the significant barriers that farmers face in FYM sufficiency and management, there is also strong evidence that farmers adapt to challenges, including the declining availability of FYM. They do this in diverse ways, based on the livelihood capitals that are available to them. Interviewed farmers believe strongly in the importance of FYM, and many have strategically adjusted their practices so they can maintain access. They do this by investing in livestock-based income opportunities, substituting with livestock that require less work but still produce some

manure, or by bulking their FYM with additional organic matter. Shed improvements increase efficiency of the livestock care process, reducing labor requirements. Other farmers adapt the FYM best practices to suit their specific needs by purpose-building labor-saving tools or creatively devising FYM storage solutions. They try to reduce nutrient loss in the field by incorporating FYM quickly, compensating in part for reduced FYM availability.

Recent work has found that adopting climate-smart agriculture practices – of which FYM improvement is one – results in increased farmer access to other livelihood capitals (Martinez-Baron et al., 2024). Bringing this together with our findings, a positive feedback loop emerges: farmers with more access to key capitals have greater ability to maintain or adopt sustainable practices like improved FYM, and farmers adopting more of these practices build more capital-resilience for themselves and their families. In this way, through targeted support for farmers to access key livelihood capitals that enable sustainable practices, rippling effects may allow farming communities to build resilience to ongoing changes in socio-economic and climate conditions.

4. Conclusion

In the midst of significant socioeconomic changes, smallholder farmers in Nepal's western mid-hills face challenges to sustain traditional FYM management and improve FYM through recommended best practices like protected FYM storage, advanced livestock sheds and efficient field application. This study brought together prior survey data and interview data (collected/analyzed by me) to identify current farmer practices and to understand the barriers and opportunities farmers face as they make FYM-related decisions. I then analyzed qualitative data within the Sustainable Livelihoods Framework, associating farmers' reported barriers and opportunities with respective livelihood capitals to locate openings for farmer support. Farmers

reported mixed implementation of FYM management strategies. Livestock husbandry is declining, presenting a foundational challenge for FYM availability. Among both the surveyed and interviewed individuals, only a minority of farmers have adopted FYM best management practices including pit storage, turning, covering, and urine separation. Instead, many are prioritizing shed improvements, which increase manure collection and livestock feed efficiencies but often result in decreased non-manure additions to FYM. Farmers are making efforts to decrease nutrient loss in the field, trying to limit FYM exposure to the elements through fast incorporation, but face challenges in doing so. Most farmers apply inorganic fertilizers alongside FYM on cropping fields but lack information and access to apply either in necessary quantities.

The barriers and opportunities faced by farmers are most commonly connected with human capital (knowledge and labor) and, less frequently but still significantly, with financial, physical and natural capital. Each of these livelihood capitals is facilitated by social capital, which reflects access, power and connection within the community, and is itself shaped by intersectional structural factors. The most impactful strategies to sustain and improve FYM management will depend on each farmer's access to livelihood capitals. To aid in identifying capitals, interviewed farmers are sorted into five categories which can guide opportunities for action. Although adoption of improved FYM practices is mixed, and socioeconomic changes including increased out-migration generate profound barriers, many farmers in this group demonstrate significant adaptability and commitment to sustaining FYM as a crop fertility strategy. By leveraging these strengths and targeting interventions to support farmers' particular needs, there is great potential for continued and even increased integration of FYM to reinforce sustainable cropping systems and resilient agricultural communities.

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Appendix A: Interview format

Farmer ID:	Date:	
Location of interview:	Start time:	End time:
Introduction and consent: Read introduction and consent language (other sheet)		
<i>Do you consent to participate and have the interview recorded?</i>	Yes / No	
<i>Is it ok if we take photographs of you and your farm to include in research? Your name will not be connected to them</i>	Yes / No	
Let's begin. Remember, there are no right or wrong answers, we want to learn from you about your farm. Feel free to ask us questions, skip questions or stop at any time.		
Warm up:		
1. Tell us about your farm (or family).		
2. In your house, who makes the most decisions about how and what to farm?		
Theme A: FYM knowledge and perceptions:		
3. In your opinion, what do you think is the most important thing farmers can do to maintain the fertility and health of their fields?		
4. Do you think it's important to use FYM in your fields? Why?		
5. From where have you received information about FYM management, and what have you learned from them?	Where:	What:
Theme B: FYM practices [<i>Visit animal shed</i>]		
6. Please explain in detail your FYM management practices , beginning with manure collection and ending with incorporation into the field.		

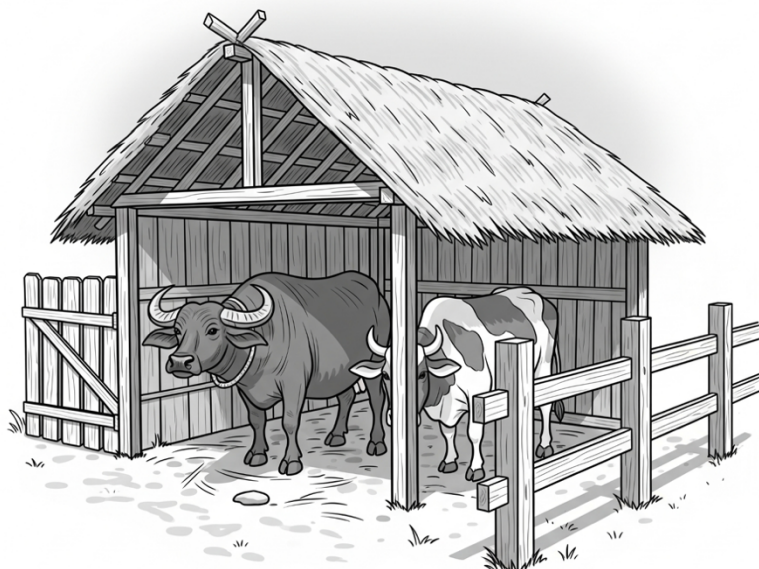
7. <i>Ask follow up questions if not answered above:</i> a. How many livestock (of which kinds) do you collect manure from? How often?	# livestock: Frequency:
b. What kind of pile/pit do you use?	Type: Details/obs:
c. Do you cover the pile/pit? How?	Y / N Details/obs:
d. Do you turn the pile/pit? How/how often?	Y / N Details/obs:
e. How long does it take between transporting the FYM to the field and incorporating it? (How long does the FYM sit on the surface?)	Time: Details/obs:
8. How have these practices changed over time on your farm? Why?	
Theme C: Barriers and motivations to adoption [Some of these questions may come up organically in the prior section. Follow up now with any that have not been addressed]	
9. Fertilizers and FYM rate: How do you decide what fertilizers (inorganic and organic) to apply to a field? Do you think you're applying enough FYM or would you like to apply more? [If no] What prevents you from increasing the amount of FYM you apply?	
10. Type of storage: Why do you use the kind of pile/pit that you do?	
11. Covering: [For adopters]: Why do you cover the pit? [For non-adopters]: Why don't you cover the pit?	
12. Turning: [For adopters]: Why do you turn the pit? [For non-adopters]: Why don't you turn the pit?	

13. Incorporation timing: How do you decide when to incorporate the FYM into the field? [For non-adopters]: What keeps you from incorporating it sooner?	
Theme D: Time/labor/resource dynamics We are now considering the tasks needed to prepare and apply FYM including manure sweeping, pile management, and transportation to the field.	
14. For all of these tasks, who helps with the work? <i>[probe: what tasks do they help with? Are they male or female?]</i>	a. Family members b. Neighbors or community members (unpaid) c. Hired help
15. Do you ever have trouble finding time to do all the work related to FYM management (manure collection, turning, transport)? Why or why not?	Trouble Y / N
16. Do you have family who have migrated away from the village? How did that impact FYM availability or how you manage FYM?	Migration Y / N
17. Have you received any support from government or other projects/programs to improve FYM management? If so, what kind?	
Theme E: Goals/recommendations	
18. Is there anything you'd like to change or improve about how you manage FYM? What would make it possible for you to make that change?	
19. Is there anything the community, government or organizations should do to help farmers improve their FYM management?	
20. Is there anything else you'd like to share, or any questions you have for us?	
Interview observations/reflections:	

Appendix B: Images from mother's group discussion. Images generated by Google (2025), Gemini 2.5 Flash.

1. गोठ वा खोर घाम र पानीबाट जोगिएको

Livestock shed is protected from sun and rain



2. गोठमल खाल्डो वा थुप्रोमा जम्मा गरिएको र घाम र पानीबाट जोगाउनका लागि छोपेको

Manure is collected in a pit or pile and fully covered from sun and rain



3. केही समयपछि गोठमल अर्को थुप्रोमा वा खाल्डोमा पल्टाएको

After a period of time, manure is fully turned into another pile



4. गोठमल खेतबारीमा ओसारेकै दिन माटोमा मिलाएको

Manure is incorporated into the field on the same day it is spread



5. लगाएको बालीका लागि चाहिने गोठेमल किसानले पुग्दो मात्रामा तयार गरेको
Farmers produce enough FYM to meet their crop requirements

