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# Rural out-migration and water governance: Gender and social relations mediate and sustain irrigation systems in Nepal

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ABSTRACT

Rural out-migration is changing agrarian political economies and natural resource governance worldwide, and gender and social relations play an important mediating role. The aim of this study is to investigate the impact of rural out-migration on collective action in farmer-managed irrigation systems, with a particular focus on household structure and gender relations.

We employ a mixed-methods approach combining a household survey (n = 377) of ten villages conducted in early 2021 with 80 qualitative interviews, 12 focus group discussions and participant observations in two villages carried out between 2015 and 2021 in Far Western Nepal. Using descriptive statistics as well as univariate and multivariate analyses, we explore migration patterns, household relations and the functionality of farmer-managed irrigation systems based on system maintenance, resource mobilization, and satisfaction of water allocation and conflict management.

Our results show that 60.7% of all households had at least one migrant in the past five years, of which 83% were male. We find that collective labor in irrigation systems is not affected by male out-migration. Absent men's labor contributions are successfully substituted by women. Furthermore, participation in water user groups or irrigation committees is significantly higher in migrant households. Lastly, the findings revealed no effect of migration on crop yields.

These results challenge the generalizability of widespread assumptions of deteriorating community-based resource management systems, and expand debates on the "loss of labor" in rural areas and the "deagrarianisation" due to rural out-migration. Our analysis contributes to current studies on migration effects on rural societies by demonstrating the sustaining role of gender and social relations in water resource governance. An important policy implication of our analysis is that women should be recognized as key actors in the agriculture and irrigation sector, and should be addressed and integrated accordingly.

## 1. Introduction

Widespread changes in the rural economy and substantial male out-migration are causing monumental shifts in rural, agrarian households of the Global South (Rigg, 2006; Sunam, 2020; Leder, 2022, 2024). In many places, migration is decreasing the dependence on agriculture due to cash remittances, and common property resource management systems are in decline (Ojha et al., 2017; Sugden & Punch, 2014; Sugden et al., 2014). However, irrigation systems remain crucial for the food security of many populations in rural areas of the world's semi-arid and arid regions. Farmer-managed irrigation systems require sustained collective action which depends on relatively stable relationships (Dietz, Ostrom, & Stern, 2003; Ostrom, 1990), shared norms and affective kinship and community relations (Nightingale, 2011; Leder, Sugden, Raut, Saikia, & Dhananjay, 2019). This holds true in the context of our study in Nepal, but it is important to note that farmer-managed

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irrigation systems can also be more individualistic, depending on different classes of farmers ranging from subsistence farming to more capitalist farming (de Bont, Komakech, & Veldwisch, 2019), and, particularly in contexts of demand-driven policies which reinforce modernization ideals (de Bont & Veldwisch, 2020). Importantly, everyday emotional engagements in collectives and communities are ambivalent (González-Hidalgo, 2020; Leder et al., 2019). Existing scholarship suggests that changes in household structure and labor relations due to male out-migration may provide not only challenges for maintaining agrarian economies, but also new opportunities for the increased involvement of women in the governance of resources (Giri & Darnhofer, 2010; Maharjan, Bauer, & Knerr, 2012; Tiwari & Joshi, 2015; Leder, 2022, 2024; Leder, Clement, & Karki, 2017; Sugden et al., 2020).

These shifts create both challenges and opportunities for community-based natural resource management systems (Leder, 2022, 2024; Maharjan, Bauer, & Knerr, 2012; Sunam & McCarthy, 2015). The aim of this paper is to show the important mediating role of gender and social relations in sustaining irrigation systems, as well as the new opportunities for historically marginalized groups in water governance. Through a study of farmer-managed irrigation systems in Nepal, we ask: *(1) How does rural out-migration affect collective action and the functionality of farmer-managed irrigation systems? (2) How do changing household structure and labor relations create possibilities for marginalized groups to engage with collective irrigation management?*

A study of the functionality of resource governance systems in the context of rural out-migration reflects deeply intertwined and changing social and labor relations (Shrestha, Pakhtigian, & Jeuland, 2023; Sugden et al., 2014; Leder, 2024). This is particularly interesting since rural out-migration is not gender neutral, given that in most parts of the world, more men than women migrate (International Labour Organization, 2020), which has demographic effects on the non-migrating population consisting predominantly of women, the elderly and children (World Bank, 2016a). As irrigation systems have been primarily run by men, excluding women through formal or informal membership rules and practices (Zwarteveen & Meinzen-Dick, 2001), one might expect that mostly male rural out-migration may lead to the degeneration and neglect of irrigation systems. Indeed, this was shown in some cases, for example, in the Taos valley in Northern Mexico (Cox, 2014) and in China (Wang, Chen, & Araral, 2016). Generalizing this effect would also align with much of the literature on deagrarianization or depeasantization, which is defined by Hebinck (2018: 227) as a "process producing social, material, and biophysical conditions that are not conducive to the reproduction of agrarian and land-based livelihoods". Scholars have described the nuances of this process, for example, in Sub-Saharan Africa (Bryceson, 2002, 2019), South Africa (Hajdu, Neves, & Granlund, 2020), Poland (Bilewicz & Bukraba-Rylska, 2021), and in international comparison (Rigg, 2006). However, scholars have also criticized the linearity of declining agriculture, and have highlighted continuities in farming (Shackleton & Hebinck, 2018). Notably, Hebinck, Mtati, and Shackleton (2018) suggest reframing the deagrarianization debate to acknowledge the importance of landscapes and the interaction among people, fields, forests, open spaces, homesteads and so forth.

In this paper, we challenge the widespread assumptions of degenerating or deteriorating natural resource management systems and deagrarianization due to rural out-migration, since these assumptions overlook the important role of female farmers' labor, and social relations more broadly. Most of the literature has broadly pointed out two differential pathways for agriculture and community-based natural resource governance in the context of rural out-migration: either towards land abandonment and the de-intensification of agriculture due to the "loss of labor" (Ojha et al., 2017; Rigg, 2006), or towards increased mechanization due to the investment of remittances to replace labor with capital (de Haas, 2006; Lewis, Biggs, & Justice, 2022; Seddon, Adhikari, & Gurung, 2002). However, not enough scholarly and policy attention has been paid to how migration-induced changes in gender and labor relations influence collective action in resource governance systems. On the one hand, the higher participation of women in these systems increases the workload for women (Kansanga, Antabe, Sano, Mason-Renton, & Luginaah, 2019; Maharajan, Bauer, & Knerr, 2012; Sugden et al., 2014), while on the other hand, it can lead to changes in authority and participation in the public sphere and local governance. This can challenge the power of the traditional elite and can contribute to social mobility in local power relations (Rao, 2013; Sijapati et al., 2017). As Sijapati et al. (2017:26) report, migration has "worked to complement changes brought about by broader political and social processes", referring to the weakening structures of patron-client relations in regard to land-based dependency, credit-based dependency, and labor relations.

We investigate the relationship between widespread rural out-migration, gender and social relations, and the functionality of farmer-managed irrigation systems. We consider gender relations in terms of intersectional relations, especially regarding age, ethnicity, class, and caste. We link the analysis of changing household structures with the participation in, and structure and functionality of farmer-managed irrigation systems in Nepal. Multi-sited households draw their resources from a variety of locations such as from their home villages, and from the places where household members migrated to. These translocal flows of capital and ideas (Greiner & Sakdapolrak, 2016) can influence the incentives and ability to engage in irrigation resource management (Pradhan, 2000; Leder, 2024). We examine these processes in (1) system maintenance (e.g. labor input for the desilting of canals), (2) external resource mobilization, (3) water allocation (e.g. between head and end-tail users), and (4) conflict management (e.g. rule enforcement and reported cases of water theft). We hope to expand on current studies on migration effects on rural societies, which tend to focus on measurable demographic changes and economic outcomes. The results from our study contribute to the literature on agrarian change, community-based natural resource management, migration and rural transformation by showing how gender and social relations mediate the relation between rural out-migration and collective action in resource governance.

In the following section, we review the existing literature on the linkages among rural out-migration, agriculture, gender and farmer-managed irrigation systems. In Section 3, we present the case of Nepal. In Section 4, we introduce our material and methods as well as the study sites. In Section 5, we introduce the study population (5.1) and present the results on the occurrence and patterns of rural out-migration (5.2), as well as migration effects on participation (5.3) and the functionality of farmer-managed irrigation systems (5.4). We close with a discussion of our results and a conclusion.

## 2. Literature review on linkages among rural out-migration, agriculture, gender and farmer-managed irrigation systems

### *2.1. Impact of rural out-migration on agriculture and community-based natural resource management*

Rural spaces are undergoing a rapid transformation in the 21st century. Market integration, increased mobility, and translocal flows of ideas and knowledge are changing peoples' livelihoods, knowledge and resource-related practices. One of the greatest changes identified is increased male out-migration. Migration affects how people engage in agriculture, their livelihood prospects, rural societies and landscapes, and gender and intra-household relationships. Many scholars have noted that out-migration from rural to urban areas and to countries which are rapidly expanding economically has led to failing small-scale agricultural systems in the Global South: irrigation systems are collapsing, land is left fallow or underutilized, cropping cycles are changing, and agricultural systems are falling into disuse (Bryceson, 2002; Jaquet et al., 2015; Ojha et al., 2017; Rigg, 2006; Sugden et al., 2014). Changes in the agrarian political economy and out-migration can lead to the restructuring of social relations, such as the gender division

of labor, and norms associated with age, class, caste and ethnicity (Maharjan et al., 2012; Leder, 2024). The impacts of labor migration on left-behind women's opportunities to participate in natural resource management are highly heterogeneous, given that their opportunities to engage in natural resource user committees are further moderated by intersecting identities like caste/ethnicity, kinship, age and economic status (Shrestha et al., 2023).

In the past two to three decades, scholars have noted a process of "deagrarianization" with youth aspirations turning from agriculture to wage labor and migration to rapidly industrializing cities worldwide (Bryceson, 2002; Rigg, 2006). This has been accelerated more recently by land deprivation processes through investments in agriculture, mining, conservation, and tourism (Bluwstein et al., 2018), and authoritarian populist regimes (Gonda, 2019). Civil society groups have critiqued that the "agricultural brain drain" has not been sufficiently addressed in recent agricultural policies – for example, in the Agricultural Development Strategy (2015–2035) of Nepal (Paudel, Bhattarai, & Subedi, 2016). The shift towards wage labor increases the role of remittances in household food security for those left behind (Seddon et al., 2002). However, a study in the Nepalese Himalayas showed that remittances do not lead to greater livelihood security, as these are intermittent and depend on the international labor market (Fox, 2016).

A range of studies have identified various and contradictory impacts of rural out-migration on agriculture and community-based natural resource management due to the lost labor effect (Gray, 2009). Studies found paradoxical effects on investments and remittances spent on agriculture, abandonment of land (Maharjan, Kochhar, Chitale, Hussain, & Gioli, 2020), agricultural land underutilization (Ojha et al., 2017), the commodification of land (Sunam & McCarthy, 2015) and reduced crop productivity. Qin and Flint (2012) found that labor-migrant households were significantly more likely to contact public or village leaders about community issues and environmental problems, and that remaining family members of labor-migrant households actively participated in community infrastructure work such as road construction and irrigation system maintenance. Studies on migration effects on forest-based communities have similarly shown variable effects on both forest resurgence and deforestation, as well as the variable effects of remittances on forest cover, biodiversity, and the use of forest products (Hecht, Yang, Sijapati Basnett, Padoch, & Peluso, 2015).

These contradictory findings have resulted in the two competing narratives of "migration optimists" and "migration pessimists" (de Haas, 2006): seeing migration either as a threat to agriculture, or as a pathway out of rural poverty. This is linked to wider debates with either a rather linear process of "deagrarianization", and the associated loss of prestige of agriculture on the one hand, and multiple studies also highlighting processes of "repeasantization" on the other (Hebinck et al., 2018; Maharjan et al., 2020; Sunam & McCarthy, 2015). We argue that a binary approach to conceptualizing migration effects is not useful given the diversity of impacts of rural out-migration, depending on the respective social, political, economic and environmental contexts at different scales (Sijapati et al., 2017). Instead, a translocal perspective of migration and environmental interactions may better reflect the complexity of relations between flows of remittances, loss and gain of labor, and social, political, economic, gender and cultural relations (Greiner & Sakdapolrak, 2013). Translocal social relations change gender, caste and class relations, which in turn shape collective irrigation system maintenance (Leder, 2024; Singh, 2019) calls for an expanded conceptualization of households, local livelihoods and climate change adaptation to include "beyond-local" flows and networks that shape household risk management behavior. Livelihood diversification through migration is a historically common adaptation strategy, even more so today in the context of climate change, as remittances help to diversify household income, spread risks and insure against external stressors (Afifi et al., 2016; Kadfak, 2020; Maharjan et al., 2020; Van der Geest, 2010)). This underlines the need for agricultural sector-specific and context-specific studies exploring the various effects of rural out-migration on resource management systems in diverse household populations.

### 2.2. The effect of migration on household structures and gender relations: towards an intersectional approach

For more than a decade, a range of critical and feminist agrarian studies have focused on the increasing labor burden and responsibilities for women in the absence of men. Studies have shown how out-migration leads to new vulnerabilities (Evertsen & van der Geest, 2020), an increased agricultural labor burden for those "left behind" (David, 1995; Gartaula, Niehof, & Visser, 2010; Sugden et al., 2014), and a continued or even deepened dependence on kinship and caste relations (Shrestha et al., 2023).

However, these processes present not only challenges, but also opportunities for the greater influence of women within agrarian households and communal spaces, and increased self-determination, while socio-spatial struggles over resources due to persistent gender norms and power relations remain(Leder, 2022, 2024; Leder, Clement, & Karki, 2017; Ravula et al., 2020). There are also possibilities for greater control over decision-making in agriculture and the household by women and other marginalized community members (Giri & Darnhofer, 2010). A study in the mid-hills of Nepal suggested that women have broadened and deepened their involvement in rural society as a result of male out-migration, but this is conditional on migration patterns and remittances received by households, as the latter help to reduce the physical work burden and increase decision-making roles (Maharjan et al., 2012).

Previous research also demonstrated how the absence of men affects intra-household relationships. The extent to which women engage in water user groups depends on whether there are other women in the household, as well as their age, class, ethnicity, and caste (Shrestha et al., 2023; Leder, Clement, & Karki, 2017). These differences suggest that the often-cited term "feminisation of agriculture" (Radel, Schmook, McEvoy, Méndez, & Petrzelka, 2012; World Bank, 2016a) tends to simplify and reduce complex social relationships to gender relations, while everyday struggles over agricultural, water and land resources remain shaped by land ownership, remittances, household position (particularly of those living with their in-laws), age, caste *and* gender relations (Leder, 2022). Extensive research in Latin America and the USA by Radel et al. (2012) has shown the importance of differentiating migration effects on farm labor and management, as these are shaped by existing gendered patterns in tenure, land-use decision-making and the management of hired labor. Studies have shown contradictory effects on restricting or promoting women's empowerment and mobility within a south-eastern community in Mexico (McEvoy, Petrzelka, Radel, & Schmook, 2012). In an international comparative study by Radel, Schmook, and McCandless (2010), more women assume aspects of land management, including in decision-making and supervision of hired farm labor in Southern Yucatán, Mexico, while in Vermont, USA, "a largely male migrant labor force helped maintain an idealized, pastoral landscape with gender deeply embedded in how that labor is constructed and managed" (Radel et al., 2010). Importantly, as research in Northwestern Nicaragua has shown, migration is an integral part of smallholder farming systems as it can finance land rental and input purchasing (Radel, Schmook, Carte, & Mardero, 2018).

This underscores the need for a gendered approach to study the linkages of migration, agriculture and irrigation (Erwin et al., 2021; Leder & Sachs, 2019). Furthermore, intersecting inequalities shape a household's risk management, well-being and adaptive capacities (Rao et al., 2020). Therefore, intersectionality is "useful to break down assumptions about female and male farmers" (Leder & Sachs, 2019). A better intersectional understanding of these social dynamics, and the ways that they influence engagement in collective action is key to identifying pathways to ensure the food and livelihood security of those left behind, particularly the poor and marginalized (McEvoy et al.,

2012).

Labor migration literature has only very recently highlighted the "spatio-temporally divided invisible economies of care" that are crucial to the exploitation of migrant laborers (Shah & Lerche, 2020). Zharkevich (2019) cautions "against posing a rigid dichotomy between 'mobile men' and 'immobile' women, illustrating that the 'left behind' wives experience an impressive degree of everyday mobility in contrast to their internationally mobile husbands". She further shows how the construction of hegemonic masculinity, represented by the "figure of a successful international migrant, is inseparable from an ideal of femininity vested in the figure of a virtuous domesticated housewife" (Zharkevich, 2019).

### 2.3. Farmer-managed irrigation systems and migration

Farmer-managed irrigation systems (FMIS) have been considered central to the sustainability of agricultural systems in Asia since the 1980s (Liebrand, 2019). The term "farmer-managed irrigation system" was introduced more widely by Martin & Yoder in 1983, building on the insights of the work of Prachanda Pradhan in Nepal. It is defined as a system that consists both of the practice of irrigation and the extent of the potential irrigated command area, with its construction, operation and beneficiaries mainly or exclusively involving groups of farmers with little or no input from government or other outside agencies (Liebrand, 2019: 134). Research by Ostrom (Ostrom, 1990) highlighted the importance of the institutional, rather than technical functionality of irrigation systems, and developed the design principles of collective action while relying on the insights and lessons from irrigation systems in Nepal with the support of Pradhan (Pradhan, 2000). The establishment of the International Irrigation Management Institute (IIMI) and significant international aid investments in farmer-managed irrigation systems have focused scholarly attention on the functionality and changes of irrigation systems since the 1990s. Migration effects on collective action in irrigation systems have been little studied. This is surprising as water resource management quickly brings into view core community-based natural resource management challenges: canal irrigation systems require continuous and high labor input for their maintenance, reflecting the immediate effects of changing political economies and management practices through water's fluid properties (Mehta, Veldwish, & Franco, 2012; Mosse, 2003), e. g. by neglect, or by the diversion of excess water to particular households.

A recent study on migration and the gender dynamics of irrigation governance by Meinzen-Dick, Pradhan, and Zhang (2022) combined a phone survey of 336 water user group leaders from all provinces in Nepal with qualitative data from case studies in 10 irrigation systems. They found striking evidence that women's attendance and speaking in water user group meetings is higher in sites with male migration, and that women are significantly more likely to be involved in supervising water distribution. They also found that systems are adapting to male migration with low idling of land or labor shortages causing deterioration of the systems, but with concerns regarding high labor burdens for women. Wang et al. (2016) found that labor migration has a statistically significant adverse effect on collective irrigation in China. They assume that rural out-migration explains the significant drop in the use of collective canal irrigation and the significant increase in groundwater irrigation since reforms introduced in the 1980s.

Research from Northern Ghana shows that causality can also go in the opposite direction, with irrigation influencing migration, rather than the other way around. In this semi-arid region, migration is a common adaptation strategy to deal with rainfall variability and food insecurity (Rademacher-Schulz, Schraven, & Mahama, 2013; Schraven, 2010). The study by Schraven (2010) showed that farmer-led development of shallow groundwater irrigation improved household incomes considerably and decreased rural–urban migration.

## 3. The case of Nepal

Nepal's agricultural sector engages 69 % of Nepal's labor force (CIA Worldfact Book 2017). Despite the continuous decline of the contribution of the agricultural sector to the Gross Domestic Product (GDP) of currently around 27 %, the agricultural sector has been a priority for the government in the current fiscal year (2021/22), with NRP 45.09 billion allocated for the sector (Ministry of Finance Nepal, 2021).

Nepal serves as an excellent case study for understanding collective action in irrigation systems and rural out-migration for three reasons. First, 40 % of Nepal's total agricultural land is irrigated, and 70 % of the irrigated areas fall under farmer-managed irrigation systems, rather than agency-run or government-run irrigation systems (Government of Nepal, 2019). The early emergence of farmer-managed irrigation systems is based on the edicts of King Ram Shah (1606–1636) that water-related conflicts shall be settled by the people themselves, and not brought to the king's court.[1] In 2000, and presumably it is still the case today, 17,000 farmer managed irrigation systems thus account for 40 % of Nepal's food production (Pradhan, 2000).[2] A wide range of studies on community-managed irrigation systems have focused on Nepal since Elinor Ostrom's ground-breaking work on the Governance of the Commons (Ostrom, 1990). Mechanisms for irrigation system maintenance, resource mobilization, water allocation, and conflict resolution have been documented over the past four decades by Pradhan, Yoder, Meinzen-Dick, and Merrey (2023) identifying dramatic changes in the functioning of six irrigation systems in Nepal due to population growth, migration, urbanization, new transport networks, and the impacts of climate change.

Importantly, gender studies in Nepal have already shown the importance of the greater involvement of women, given that this strengthens the effectiveness of local irrigation governance (Zwarteveen & Meinzen-Dick, 2001). Shrestha and Clement (2019b) found that dominant discourses, formal rules and professional culture in the water sector in Nepal reproduce hegemonic masculine attitudes and practices of water professionals. Such attitudes and practices in turn favor a technocratic implementation of policy measures. Initially, and rather early in the international comparison, Nepal's Irrigation Policy of 1992 required 20 % of women in water user groups, and the 2013 Amendment to Nepal's Irrigation Policy (2003) stresses that water "user association shall be composed of at least thirty three percent of the women representation as well as, there shall be representation of Dalit, downtrodden […] ethnic communities" (Government of Nepal, 2003). However, several studies indicate that the gender quota is often not reached in water user groups (Pradhan, 2016), and if it is, that formal "participation did not automatically translate into voice and power" (Udas, 2014: 234). Nevertheless, after the decade-long civil war ending in 2006, irrigation institutions have become more inclusive in terms of caste, though not for women overall (Panta & Resurrección, 2017).

Second, Nepal's rural areas are highly affected by a shortage of farm labor as one-third of Nepal's male working population has out-migrated, with remittances accounting for 33 % of GDP, the second highest proportion globally (World Bank, 2016b).

Third, Nepal is an excellent case for studying collective action within the decentralization of government arrangements: a new government

[1] The edict of King Shah, King of Gorkha (1606–1636), rule 8 reads: "His Majesty has ordered not to hear a petty case relating to the Kulo (a small canal to irrigate the field). That is because mostly the helping people are engaged in the irrigation of the land. Therefore, use your portion of water only in your turn. Do not use water except in your turn and never use it more than your portion. If there arises a minor dispute – do not bring it to the Kachahari; this is the Rule issued by His Majesty." https://www.lawcommission.gov.np/en/wp-content/uploads/2018/09/rules-issued-by-ram-shah.pdf.

[2] Despite this estimate being more than two decades ago, the author confirmed its validity today.

structure was introduced in 2017 and local representatives in 752 municipalities were elected, bringing hope for better accountability at the local level. The planned availability of irrigation funds at the municipality level is a reason why this study will receive particular interest among policy makers and practitioners in the country. While these structures at the local level (municipality and rural municipality) are publicly elected and exercise a degree of autonomy regarding development planning in their jurisdiction, they do not have the same technical expertise in agriculture and irrigation as the previous district agriculture development offices (DADO) and their agriculture extension services (Dahal, Karki, Jackson, & Panday, 2020). Municipality and rural municipality have predominately administrative functions, and the lack of technical, human, or financial resources at the new Agriculture Knowledge Centres curtails their effectiveness and efficiency in providing agriculture extension services (Devkota & Thapa, 2019).

## 4. Material and methods

We employ a mixed-methods approach combining a household survey (n = 377) of ten villages in February 2021 with 80 qualitative interviews, 12 focus group discussions and participant observations between 2015 and 2021 in two districts, Doti and Dadeldhura, Far Western Nepal. The survey questionnaires are based on prior extensive qualitative research undertaken in two of the villages since 2015, and were piloted with 9 households. The interviews took approximately one hour each and were conducted in Nepali and the local language Doteli by five research assistants. The questionnaire comprised of closed-ended questions generating quantitative information on socio-demographic household characteristics, migration occurrence, patterns and subjective perceptions regarding migration effects on household, community relations, and agriculture, as well as data on the structure, participation and functionality of farmer-managed irrigation systems.[3] As we are aware of the complexity and embeddedness of farmer-managed irrigation systems within rural villages, the questionnaires covered a range of additional factors which could determine the involvement in farmer-managed irrigation systems, such as land ownership, crop yield, irrigation practices and collective labor arrangements. Using descriptive statistics as well as univariate and multivariate approaches we explore the linkages between migration occurrence, household structures (with a focus on gender) and collective water management practices.

In addition to the questionnaire, in two villages, we conducted 80 qualitative interviews with female and male farmers of different castes, and differing land ownership and irrigation management practices. We also facilitated 12 focus group discussions as well as participant observations and transect walks over a period of six years with four two-week-long visits in 2015, 2016, 2020 and 2021. Based on our qualitative interviews, committee records and observations, we documented the histories and functionality of each irrigation system. All data was translated into English, and we applied qualitative content analysis with the software NVivo.

### 4.1. Study site selection

We purposely selected the ten villages as they represent socio-demographic and topographic characteristics for the hill population in Far Western Nepal. The Far Western region's Human Development Index (HDI) has consistently been below the national average in the last two decades (1996, 2001 and 2011), indicating a lower literacy status and mean age at school, lower purchasing parity per person (PPP) and lower life expectancy at birth than elsewhere (Dhungel, 2018).

Rural out-migration is common in all villages and across all castes (Chhetri, Dalit and Brahmin), and land holdings were small and fragmented across the rugged terrain. The villages represent a diversity of irrigation systems covering canal irrigation systems as well as collectively managed ponds for irrigation. We built on six years of prior research with in-depth knowledge of the sites and well-established contacts which helped to decide on additional villages which were accessible for the research team within one hour's walk from the main road. This could represent a sampling bias in that more remote villages in higher mountain areas have very different results in terms of their functionality of collective irrigation systems, as repair and maintenance might be more challenging due to long transport distances by foot. Our research builds on a range of studies in which the lead author was involved investigating women's empowerment, water and food security in several villages which we covered in our survey (Buisson, Clement, & Leder, 2022; Clement, Buisson, & Leder, 2019; Leder, Clement, & Karki, 2017; Leder & Sachs, 2019).

The survey was conducted in two different districts (Doti and Dadeldhura) which are differently affected by the implementation of the Nepal's Irrigation Master Plan (Government of Nepal, 2019). With the intervention of the federal state some villages (like Tiltali in Doti) have better irrigation facilities and thus better agricultural productivity compared to others (like Selinge and Mudrad in Dadeldhura) where communities scramble for water flowing through a single stream often leading to upstream–downstream conflict. Such social complexities present an opportunity to gain insights into how collective actions function differently.

In the Doti district, the survey covered randomly selected households in 9 toles (housing sections based on ethnicity or caste) along a 6.5-km cemented canal irrigation system which was initiated by a well-off Chhetri family, and then significantly funded under the 2nd Hill Irrigation Project by the Asian Development Bank in 1989. The canal has 9 outlets which are opened in a rotating system in which two outlets are opened at a time to supply 1–3 toles with water, depending on the size of land (FGD with the irrigation committee in Feb. 2020). In 2017, the newly established provincial government rebuilt and repaired 315 m of the canal with a budget of about 70 000 EUR, but the current irrigation committee of 9 members (one representative per tole) stated that they required double the amount in order to fully repair the canal during our field visit in February 2020. The canal supplies water to a total of 400 households who pay 30 NPR (0,21 EUR) monthly maintenance fees, whereas, according to the committee, each of the 200 households sends one household member to provide labor and participate in the yearly collective canal cleaning and repair days in May to prepare for the paddy plantation in monsoon. The remaining 200 households pay an annual fine of 80–100 NPR (0.56–0.70 EUR) for non-participation. The rules are enforced by the tole representative of the irrigation committee, who informs all households about both labor and the financial requirements of the irrigation canal use.

In the district of Dadeldhura, the survey covered randomly selected households in 9 villages spread across a rugged terrain (1600 m altitude) which had a range of functional, non-functional and non-existent irrigation committees in each village, managing either irrigation canals or ponds for irrigation. The functionality is dependent on existing funds for building, repairing and maintaining irrigation infrastructures through government or international aid funding. In the case where there were ponds, for example, their establishment required local leaders who formed a committee in order to apply for or negotiate funding. Recurring observations during our field visits were that these irrigation committees dissolved when they were not officially called for meetings by the government or NGOs. This often impacted the overall functionality of irrigation management unless there was strong agency by a few local leaders. Several internationally funded climate adaptation programs funded and implemented individual household taps for multiple use, which were, however, mostly used for domestic purposes, and less so for vegetable garden irrigation as also intended. During our visit in

[3] Participation and functionality were assessed based on three answer options: (1) No, (2) Yes a bit, (3) Yes, a lot. Based on these answers we analyzed responses according to three scales: low, middle and high degree/low, some and great extent.

February 2020, we observed that an agricultural cooperative and members of a drinking water committee joined forces to apply for local government funding for ponds and pipes. They stated they would repair and maintain the newly set up ponds collectively with the 10–12 households participating. They were taking turns on irrigating their land every three days. The newly set-up ponds would ensure their food security for three months a year.

## 5. Results

### 5.1. Study population

Table 1 shows the socio-demographic characteristics such as caste, gender, age, dependency ratio, income, land ownership and migration status of the households we interviewed in the two study districts of Doti and Dadeldhura. In Doti, 77.8 % were of the Chhetri caste and 21.7 % were Dalits, with only 0.5 % Brahmin (1 household), while in Dadeldhura, 70.6 % were Chhetri, 18.7 % were Dalit, and 10.7 % were Brahmins (10 households). The mean household size was 5.4 members.

The mean dependency ratio[4] based on age is 0.27, indicating that on average per household 27 % of the household members were either children 0–15 years or elderly > 65 years, both of whom are dependent on the age group of 16–64 years. However, 53 % of the household members were without regular or seasonal income, which shows that many more people than the 27 % which the dependency ratio suggested depend on a small economically active group (of only 47 %).

Land ownership varied across the districts with a lower mean average of 3.1 katha (0.16 ha) per household in Doti, and 4.8 katha (0.24 ha) per household in Dadeldhura. The lower land ownership but higher income in Doti can be explained by higher remittances than in Dadeldhura.

Interestingly, while in Doti almost all households (96.8 %) share water taps with other households, 56.1 % of households in Dadeldhura have their own water tap. Univariate comparisons regarding the study population characteristics between Doti and Dadeldhura are presented in Table 1.

### 5.2. Migration occurrence and patterns, and its gendered implications

The districts varied significantly in the occurrence and patterns of migration (Table 2). While in Doti, 69.8 % of all households have had at least one migrant in the past five years, in Dadeldhura, it was only 52.4 %. In Doti, there is also a higher occurrence of migrants within a household with an average of 1.24 migrants per household, while in Dadeldhura, the value is 0.91. The proportion of migrants per the economically active age group of 16–64 years is 0.33 in Doti, and only 0.2 in Dadeldhura. This means that on average, one out of every three persons in the 16–64 age group had migrated at some point in the past five years in Doti, whereas in Dadeldhura, it is one out of every five persons.

Migration is highly gendered as 83 % of the migrants were male. The gender ratio in the households overall (including members currently living elsewhere) was about equal, but the gender ratio changes to 57.7 % female to 42.3 % male household members as a result of male migration (see Table 1). Male dominated migration patterns are gradually shifting as women make their way into productive, income-generating work.

> "In the past, only men worked, I was very skeptical when my daughter mentioned she wanted to join police force […] however, she was very firm on her decision. She was the first women from the

[4] The mean dependency ratio is the ratio of children (0–15 years) and elderly (65+ years) to those typically in the productive ages (16–64 years) across all households.

**Table 1**
Socio-demographic household structures in two study districts (hh = households).

| | Total (377 hh, 2035 persons) | Doti (189 hh, 1011 persons) | Dadeldhura (187hh, 1024 persons) | p-value (Doti vs. Dadeldhura) with Chi-Square or Mann-Whitney-U according to data |
|---|---|---|---|---|
| **Caste % (n)** | | | | <0.001 |
| Brahmin | 5.6 % (21) | 0.5 % (1) | 10.7 % (20) | |
| Chhetri | 74.2 % (280) | 77.8 % (147) | 70.6 % (132) | |
| Dalit | 20.2 % (76) | 21.7 % (41) | 18.7 % (35) | |
| **No. of household members** | | | | 0.73 |
| Mean (SD) | 5.4 (2.2) | 5.3 (2.1) | 5.5 (2.3) | |
| Median (Q25; Q75) | 5 (4;6) | 5 (4;6) | 5 (4;7) | |
| Range | 1–13 | 1–13 | 1–13 | |
| **Migrant (at least 1) in household** | | | | <0.001 |
| Yes | 60.7 % (229) | 69.3 % (131) | 46.5 % (87) | |
| No | 38.7 % (146) | 30.7 % (58) | 52.4 % (98) | |
| Missing | 0.5 % (2) | 0 | 1.1 % (2) | |
| **Gender % (n)** | | | | 0.79 |
| Female | 50.2 % (1025) | 50.5 % (511) | 50.0 % (511) | |
| Male | 49.6 % (1011) | 49.1 % (496) | 50.0 % (512) | |
| Third gender | 0.04 % (1) | 0.1 % (1) | 0 | |
| Missing | 0.1 % (3) | 0.2 % (3) | 0 | |
| **Gender ratio per household (% of females in households)** | | | | |
| Mean (SD) | 0.51 (0.17) | 0.51 (0.16) | 0.51 (0.17) | |
| Median (Q25; Q75) | 0.5 (0.4;0.6) | 0.5 (0.4;0.6) | 0.5 (0.4;0.6) | |
| Range | 0–1 | 0–1 | 0.17–1 | |
| **Gender ratio of those living full time in household** | | | | |
| Female | 57.7 % (948) | 59.4 % (470) | 56.0 % (475) | |
| Male | 42.3 % (696) | 40.6 % (321) | 44.0 % (373) | |
| Mean (SD) | 0.6 (0.21) | 0.62 (0.21) | 0.58 (0.20) | |
| Median (Q25; Q75) | 0.57 (0.5;0.71) | 0.6 (0.5;0.75) | 0.5 (0.5;0.67) | |
| Range | 0–1 | 0–1 | 0.2–1 | |
| **Gender ratio of migrants per household** | | | | |
| Female | 20 % (77) | 19.2 % (41) | 21.2 % (36) | |
| Male | 80 % (308) | 80.8 % (173) | 88.8 % (134) | |
| **Age of household members % (n)** | | | | 0.23 |
| 0—10 years | 17.6 % (359) | 18.1 % (183) | 17.3 % (176) | |
| 11—20 years | 22.8 % (466) | 23.5 % (237) | 22.0 % (226) | |
| 21—30 years | 19.4 % (395) | 17.9 % (181) | 20.9 % (214) | |
| 31—40 years | 13.7 % (279) | 14.2 % (143) | 13.3 % (136) | |
| 41—50 years | 10.5 % (215) | 10.8 % (109) | 10.2 % (104) | |
| 51—60 years | 6.7 % (137) | 5.7 % (58) | 7.7 % (79) | |

(continued on next page)

**Table 1** (*continued*)

| | Total (377 hh, 2035 persons) | Doti (189 hh, 1011 persons) | Dadeldhura (187hh, 1024 persons) | p-value (Doti vs. Dadeldhura) with Chi-Square or Mann-Whitney-U according to data |
|---|---|---|---|---|
| 61—70 years | 5.3 % (108) | 6.1 % (62) | 4.5 % (46) | |
| ≥71 years | 4.0 % (81) | 3.7 % (37) | 4.2 % (43) | |
| **Dependency ratio (0–15+>65 year-old pop. vs. 16–64 year-old pop.)** | | | | 0.23 |
| Age 0–15 OR > 65 | 25.3 % (516) | 26.5 % (268) | 24.1 % (247) | |
| Age 16 to 64 years | 74.7 % (1524) | 73.5 % (742) | 75.9 % (777) | |
| Mean (SD) | 0.27 (0.25) | 0.28 (0.26) | 0.26 (0.25) | |
| Median (Q25; Q75) | 0.25 (0;0.4) | 0.25 (0;0.43) | 0.22 (0;0.37) | |
| Range | 0–1 | 0–1 | 0–1 | |
| **Income dependency (% of those with regular/seasonal income in hh)** | | | | 0.89 |
| Regular/ seasonal income | 47.0 % (956) | 47.2 % (476) | 46.8 (477) | |
| Without income | 53.0 % (1079) | 52.8 % (533) | 53.2 % (543) | |
| Mean (SD) | 0.45 (0.21) | 0.45 (0.21) | 0.45 (0.21) | |
| Median (Q25; Q75) | 0.5 (0.33;0.6) | 0.5 (0.33;0.6) | 0.5 (0.33;0.6) | |
| Range | 0–1 | 0–0.83 | 0–1 | |
| **Land owned (per hh)** | | | | <0.001 |
| Mean (SD) | 3.95 (4.9) | 3.1 (4.3) | 4.8 (5.3) | |
| Median (Q25; Q75) | 2 (1;5) | 2 (0.5;4) | 3 (1;6) | |
| Range | 0–35 | 0.1–33.28 | 0–35 | |
| **Total Annual income** | | | | <0.001 |
| Mean (SD) | 293 988 (850016.9) | 380 755 (1 172 722) | 206 450 (218 405.1) | |
| Median (Q25; Q75) | 200 000 (70 000;350 000) | 269 000 (131 500;398 000) | 150 000 (50 000;300 000) | |
| Range | 10 000–16 000 000 | 20 000–16 000 000 | 10 000–1 500 000 | |
| **Own household water** | | | | <0.001 |
| Yes | 29.4 % (111) | 2.6 % (5) | 56.1 % (105) | |
| No/ shared | 69.5 % (262) | 96.8 (183) | 42.2 % (79) | |
| Missing | 1.1 % (4) | 0.5 % (1) | 1.6 % (3) | |

village to join the force and needs to travel to different districts for work. Many girls in the village are also being inspired by her, they also want to work like her when they grow up" (older male, Dadeldhura).

Long-term migration (>6 months/year) is more prevalent in Doti (74.7 %), while in Dadeldhura, the value is 68.4 %. The remaining percentage were seasonal migrants (<6 months/year). Migrants' destinations also varied: in Doti, 20.9 % migrated domestically, 61.3 % migrated to neighboring India, and 16.6 % migrated to another country abroad with a majority going to Dubai in the United Arab Emirates, but destinations also included Malaysia, Saudi Arabia, Qatar, Kuwait and the USA. In Dadeldhura, more than half of all migrants migrated at least once domestically (53.2 %), while 34.5 % migrated to India, and 17.5 % to another foreign country. Remittances make up a very large part of household incomes, particularly in Doti. The median annual income without remittances per household in all sites is 213 EUR,[5] and with remittances 1860 EUR. In Doti, income without remittances is only 213 EUR, and with remittances 2389 EUR. In Dadeldhura, the median income without remittances is 284 EUR, and 1388 EUR including

**Table 2**
Migration occurrence and patterns (hh = households).

| | Total (377 hh) | Doti (189 hh) | Dadeldhura (hh187) |
|---|---|---|---|
| **Migrant (at least 1) in hh in the last five years** | | | |
| Yes | 60.7 % (229) | 69.8 % (132) | 52.4 % (98) |
| No | 38.7 % (146) | 30.2 % (57) | 46.5 % (87) |
| Missing | 0.5 % (2) | 0 | 1.1 % (2) |
| **Number of migrants per hh (n = 406 migrants) in the last five years** | | **235 migrants** | **171 migrants** |
| 0 | 39.0 % (147) | 30.2 % (57) | 47.6 % (89) |
| 1 | 34.0 % (128) | 37.6 % (71) | 30.5 % (57) |
| 2 | 16.2 % (61) | 19.6 % (37) | 12.8 % (24) |
| 3 | 5.3 % (20) | 6.3 % (12) | 4.3 % (8) |
| 4 | 2.4 % (9) | 3.2 % (6) | 1.6 % (3) |
| 5 | 3.2 % (12) | 3.2 % (6) | 3.2 % (6) |
| Av. Mig per hh | 0.93 | 1.24 | 0.91 |
| **Migrant ratio (number of migrants/hh members aged 15–64)** | | | |
| Mean | 0.27 (0.28) | 0.33 (0.31) | 0.21 (0.24) |
| Median (Q25;Q75) | 0.25 (0;0.5) | 0.33 (0;0.5) | 0.2 (0;0.33) |
| Range | 0–2 | 0–2 | 0–1.25 |
| **Migrant gender ratio (number of female migrants/sum of migrants)** | | | |
| Female | 17.0 % (69) | 17.4 % (41) | 16.4 % (28) |
| Male | 83 % (337) | 82.6 % (194) | 83.6 % (143) |
| Mean (SD) | 0.1 (0.2) | 0.1 (0.2) | 0.09 (0.2) |
| Median (Q25;Q75) | 0 (0;0) | 0 (0;0) | 0 (0;0) |
| Range | 0 –1 | 0 –1 | 0–1 |
| **Type of migration** | | | |
| Long term | 72.0 % (291) | 74.7 % (174) | 68.4 % (117) |
| Seasonal | 28.0 % (113) | 25.3 % (59) | 31.6 % (54) |
| **Migrants' destination (n = 406 (% of all migrants); multiple answering options-> over 100 % possible** | | | |
| Nepal/domestic | 34.5 % (140) | 20.9 % (49) | 53.2 % (91) |
| India | 50.5 %0.8% (205) | 61.3 % (144) | 34.5 % (59) |
| Another foreign country | 17.2 % (70) | 16.6 % (39) | 17.5 % (30) |
| **Income without remittances** | | | |
| Mean (SD) | 80 669 (165 140.4) | 73 634 (154 827.6) | 91 859 (180 121) |
| Median (Q25;Q75) | 30 000 (6 250;71 500) | 30 000 (6 000;60 000) | 40 000 (10 000;88 000) |
| Range | 0–1 500 000 | 0–1 500 000 | 0–1 500 000 |
| Missing | 131 (34.7 %) | 43 (22.8 %) | 88 (47.1 %) |
| **Income with remittances** | | | |
| Mean (SD) | 290 195 (253 140) | 336 465 (274 918.5) | 226 223 (201 416.9) |
| Median (Q25;Q75) | 262 000 (128 500; 390 000) | 305 000 (150 000; 421 500) | 195 500 (70 000;300 000) |
| Range | 0–1 600 000 | 0–1 600 000 | 0–1 340 000 |
| Missing | 141 (37.4 %) | 50 (26.5 %) | 91 (48.7 %) |

[5] NPR were converted into EUR based on the exchange rate on Feb. 1, 2021, source: https://www.exchangerates.org.uk/NPR-EUR-spot-exchange-rates-history-2021.html.

remittances.

Male out-migration – largely framed as detrimental to women's already disproportionate care responsibilities (Meinzen-Dick et al. (2022) – has been portrayed as an inescapable reality with both negative and positive consequences by the participants of the study. In our interviews, migration was frequently stated as a necessity for survival and food security: "We need money to survive. So, they (young men) migrate", (older male, Dadeldhura). Other economic reasons stated were to pay back loans for a house or medical expenses. There were also comments reflecting the sense of having no choice but to leave the village: "In Nepal, we do not have much money, what else can they do even if they stay back. So, I think it is fine even if they go. If they earned enough here, why would they want to migrate?" (male, Dadeldhura). In a Focus Group Discussion with 7 migrants' wives in Doti (5 Chhetri, 2 Dalit), diverse positive and negative perspectives on migration were stated:

*W1*: "Now we have a regular income source. We do not have problems related to fulfilling basic needs (anymore). We don't have to take out a loan now as we are having money." (46:52)

*Interviewer/translator*: "Do you all agree with what she said?" (47:58)

*W2:* "Instead of migrating to foreign land in search of work, it is good if someone stays here in Nepal. One should learn some useful skills to […] generate their own income source in their own country." (48:17)

*Interviewer/translator*: "Why do you feel so?" (48:34)

*W2*: "Why do you have to become a foreigner's slave? Let us do something here." (49:08)

*W3*: "It's very difficult in foreign land. Money does not grow there; one must work very hard to earn. (49:12) (…)

*W4*: "They might get sick or unwell while working, that bothers us so much." (49:47) (…)

*W5*: "Our husbands are facing so many problems while working for foreign companies. But at the end of the day, the hard-earned money (remittance) they send is just sufficient for us to fulfil our basic needs." (50:50)

The women also stated diverse effects on their workload and their agency (e.g. their ability to negotiate with others). One woman stated that her workload has increased overall and that she would do parma (work exchange) instead of him in his absence, and that women would need to work longer hours than men in parma, or receive a lower wage for local government work, for example, carrying rocks for building ponds or roads (500 NPR for men, 150–250 NPR for women). Although the Constitution of Nepal 2015 ensures the right to equal wages, gender-based wage discrimination is widely prevalent, particularly in rural areas, where women's wages are lower by 25–50 % than men's (UNESCO, 2015). Other women stated:

*W1*: "Well, when my husband was around, he would always make me work also. So it's the same."

*W2*: "Now, I can make my own decisions and go around also."

*W3*: "Well in my case, my husband and I used to work together before." (…)

*W4*: "In most of the households, if the husband is around both husband and wife work together but if the husband isn't around workload increases for women." (1:17:49)

Male out-migration has also reinforced the gender segregated division of agricultural work such as planting, weeding, and harvesting for women, and ploughing for men. As ploughing is culturally forbidden for women, male labor for ploughing becomes high in demand and hence becomes monetized, whereas women engage in collective labor exchange practices ("parma").

"Women need to work in the field from morning to evening, especially during the harvest season, but we aren't paid, only men are paid, they limit themselves to ploughing" (female farmer, Doti).

Very few women from remittance-receiving households invested their savings in small businesses. Livestock rearing was more common among this group, as we observed during the fieldwork. "My brother-in-law migrated to Dubai and has been sending regular income to his wife. With the money she received, she is now involved in goat farming and earns some additional income for our family", (female, Doti).

Overall, rural out-migration was seen as a key livelihood strategy that gave households more income security. However, this comes with significant downsides, particularly for women. Many of the women we interviewed voiced that they experience a higher labor burden in the men's absence, and that they worry about their children's future and the safety of their absent husbands or sons.

### 5.3. Migration effects on participation in farmer-managed irrigation systems

Of all households in the two study sites, 11.9 % are involved in irrigation committees, namely the overall governing body of an irrigation system. A total of 226 households (83.7 %) are involved in water user groups, the smallest unit of members who govern their water in collaboration with other households nearby. It is notable that in Doti, the district with higher out-migration, 92.3 % of all surveyed households are members of a water user group, whereas in Dadeldhura, only 71.9 % of households are members. In Dadeldhura, 21.2 % are part of an irrigation committee, while this figure is only 5.1 % in Doti. The reason for this difference is that in Dadeldhura, several more irrigation committees exist, and therefore, more spaces are available.

The participation in a water user group or irrigation committee is significantly higher when there has been a migrant in the household in the past five years (Table 3). Using multivariate logistic regression, factors associated with the participation in water groups were identified. Having at least one migrant in the household (compared to having none) was significantly associated with higher odds of participating in a water user group (Odds Ratio (OR): 2.9, 95 %CI [1.7;4.9]). Our findings also show an important caste angle: Compared to the Brahmin caste, households which belong to the Chhetri (OR: 0.2; 95 %CI [0.02;0.6]) or the Dalit caste (OR: 0.2; 95 %CI [0.02;0.7]) had statistically significant lower odds for participating in a water user group. This means that Brahmins, despite their low population numbers compared to Chhetris and Dalits, are more likely to be a member of water user groups. Furthermore, larger household size (expressed by the number of non-migrant household members) was also significantly associated with participation in water groups. Compared to households with an equal

**Table 3**
Participation of FMIS.

| Variable | OR (95 %CI) |
|---|---|
| **Migration** | |
| No migrant (ref.) | 1 |
| Migrants | 2.9 [1.7;4.8] |
| **Caste** | |
| Brahmin (ref.) | 1 |
| Chhetri | 0.2 [0.02;0.6] |
| Dalit | 0.2 [0.02;0.7] |
| **Land owned in katha** | |
| ≤1 (ref.) | 1 |
| >1 - ≤2 | 1.5 [0.8;3.2] |
| >2 - ≤5 | 1.3 [0.7;2.7] |
| >5 | 1.6 [0.8;3.2] |
| **Non-migrant hh members (above 15 years)** | |
| 0–1 (ref.) | 1 |
| 2–3 | 2.5 [1.3;4.8] |
| >3 | 2.0 [1.0;4.0] |
| **Gender ratio non-migrant adults** | |
| Equal (ref.) | 1 |
| More males | 1.2 [0.6;2.7] |
| More females | 1.8 [1.1;3.0] |

adult gender structure, households with a higher share of female household members had a statistically significant higher chance (OR: 1.8; 95 %CI[1.1;3.0]) of being members of a water user group. This association did not exist for households with more male non-migrant members. No statistically significant associations were seen for land owned per household. All results of the multivariate logistic regression are presented in Table 3.

A female member of the water user group told us how women are increasingly gaining confidence like herself: "I was first shaking when talking to men. Now I'm able to express myself more freely. Before men were higher, now when they are not there, I can handle cash", (FGD, Doti).

Nevertheless, a total of 73.3 % agree/strongly agree with the statement "Left behind families have increased difficulties in irrigation/water user groups", whereas 16 % disagree. There are regional variations: in Doti, only 68 % of households with migrants agreed, whereas households without migrants agreed to a significantly higher degree (80.7 %). In Dadeldhura, only a minor difference was observed between households with migrants (75.5 %) and without migrants (74.7 %).

### 5.4. Migration effects on the functionality of farmer-managed irrigation systems

The source of irrigation water in Doti is accessed through a cemented canal (67.2 %) and deep tube wells (12.2 %), and rather less through ponds (5.8 %) or river water (3.2 %). In Dadeldhura, irrigation water is accessed through cemented canal (41.7 %), ponds (15.5 %), river water (23.5 %), and only through very few deep tube wells (3.7 %). The latter is attributed to the steeper slopes in Dadeldhura.

In our survey, we also asked if someone else took over irrigation after the migration of a household member, differentiated by water source. Regarding canal irrigation, 22.4 % reported yes; regarding pond management, 37.5 % reported yes.

While in our study most households stated having a decreased crop yield in the past five years, migrant households did not report a decrease in crop yield (58 %) significantly more often than non-migrant households (52 %). Of households with migrants, 18.8 % stated that they kept the same production and 18.8 % stated they increased their production. Of households without migrants, 18.5 % stated the same production and 17.8 % stated a decrease.

To identify the functionality of irrigation system maintenance in depth, we examine (1) irrigation system maintenance (labor and financial contributions, meeting attendance at water user groups and irrigation committees), (2) external resource mobilization, (3) water allocation and (4) conflict management.

(1) Irrigation system maintenance

Regarding *labor contribution*, 97.3 % in Doti and 83.5 % in Dadeldhura stated being involved a lot in cleaning the main canal or pond, with similar responses for repair work at the canal or pond. Our qualitative interviews also confirm that collective labor in irrigation canal maintenance is not affected as sufficient labor is available in households and villages. However, it is women and the elderly rather than (young) men who increasingly provide their labor inputs. As one woman stated in an interview: "If there's a blockage in the canal, we women go together to repair the canal, before only men did". Similarly, in a focus group discussion with a water user group in Doti, the chair said: "We have no problem to mobilize labor (because of migration)". It is important to note, however, that there is still the discriminating cultural practice of chhaupadi in Nepal which does not allow women to touch water sources and be involved in canal maintenance and irrigation during menstruation, as they are considered to be 'polluted'. This practice was outlawed by Nepal's Supreme Court in 2005, and those enforcing it are meant to be punished since 2017 – however, the cultural practice continues to exist and affect most women involved in irrigation.

Similarly, *financial contributions* are functional in both districts. They were, however, higher in Doti, as 95.3 % households paid membership fees for the water user group and infrastructure repairs to a high degree, and 93.3 % paid a penalty fee when not contributing to labor needed to clean and maintain the canal. This was significantly lower in Dadeldhura, where 70.6 % paid membership fees, and slightly more, 73.4 %, paid infrastructure fees to a high degree, and even 75.2 % paid penalty fees to a high degree.

Regarding *meeting attendance at water user groups*, no striking differences were found between the districts. Overall, 56.7 % of all members stated that they attended group meetings "a lot", 20.9 % "a bit", and 16.5 % did not attend meetings. Almost all attendees stated that they speak up in meetings and contribute ideas on water-related issues, which is contrary to much literature stating passive participation in meetings (Udas, 2014). Based on our observations, this seemed true for many cases, as we perceived women, who made it into the water group, to be just as outspoken and well-networked within the village and beyond as men. We also found that those paying contributions and providing labor hold a higher ownership within the group and therefore are willing to actively discuss and contribute to decisions. Women's growing confidence is also due to multiple international food and water security projects[6] promoting women's empowerment through vegetable farming, requiring women's presence in groups as well as women-focused training sessions in horticulture, drip irrigation and similar skills and technologies. However, as one woman stated in an interview, in households like hers where there is still a man staying at home, women do not attend meetings but rather "get information about what happened in the meeting through male members". This indicates that women's participation in group meetings is more likely in men's absence.

The *meeting attendance of irrigation committees* is considerably higher, with all but one member in Doti and Dadeldhura respectively not attending, and the great majority attending to a high extent. This reflects the importance and ownership of being a committee member, for which only reliable village representatives are selected.

A change of committee members during their tenure was observed by 46.7 % in Doti to a higher extent, and 6.7 % stated no change. In Dadeldhura 28.6 % stated a higher extent of change, with 42.9 % of no change of committee members, which reflects a higher persistence of membership. Interestingly, the changes occurring were linked to changes in gender and caste-based memberships, which reflects the fact that adjustments in membership were carried out to comply with the government (or NGO project) quotas for women (33 %) and Dalits (officially required proportionally to residence). In the irrigation committee in Doti, not one of the 15 members changed their household member's representation in the irrigation committee after the migration of a family member. These findings were also confirmed by the irrigation committee chair who noted that they never had a member change because of out-migration, but rather due to other causes such as sickness or other personal reasons. In Dadeldhura, two out of 25 committee members stated having replaced the migrated family member in the user committee.

(2) External resource mobilization

In terms of *resource mobilization*, a total of 29.1 % relied a bit and 58.5 % relied a lot on irrigation improvement from the government. However, 62 % stated not lobbying or engaging with any water authorities outside their water user group. However, in Dadeldhura, 43.5 % stated lobbying a bit or a lot, whereas in Doti, only 29.3 % stated doing so. This reflects stronger ties to the local government in Dadeldhura which was also observed and reported during our qualitative

[6] In the past decade, the USAID funded project "MAWTW" as well as a DFID-funded project "Anukulan" targeted several of the villages surveyed.

interviews. This, however, reportedly changed after the decentralization efforts of the Government of Nepal starting in 2017, as the re-arrangements of responsibilities led to the location of the agricultural unit being moved a three day walk away from the villages, rather than a one day walk as it was before. These contradictory outcomes to the initial efforts to decentralize have been particularly felt in the villages we surveyed in Dadeldhura. Similarly, in Doti, major repair work at the irrigation canal was sometimes funded by the municipality or the Government of Nepal, and the chair seemed to have good channels to the responsible officers at their municipality. There was, however, a similar concern to in Dadeldhura that this might change under the ongoing decentralization efforts of the Government of Nepal, as one major aim of the government was to make irrigation funds better accessible and accountable at the municipal level. The villages we surveyed in Doti were more closely connected to the agricultural unit than most other villages in Doti, and there was a concern that their privilege of receiving funds easily due to political ties would decrease under new decentralized government arrangements.

We also observed a higher degree of incomplete irrigation projects funded by the government and international funding agencies in Dadeldhura which we also observed during our repeated field visits from 2015-2021.[7] Hence, despite their membership in a water user group, 34.9 % in Dadeldhura stated not having received improved access to canal water, whereas this was stated in Doti by only 18.7 %. Irrigation training was only received by a minor group of 7.8 % of respondents, with 10 households respectively in each district.

(3) Water allocation

An important difference was the perceived sufficiency of available irrigation water for the households' agricultural needs. In Doti, 83.3 % stated the irrigation water as being sufficient to a great extent, and 12 % reported sufficiency to some extent. In Dadeldhura, only 45.5 % stated having sufficient irrigation water to a great extent, 19.4 % to some extent, and 31.5 % stated not having sufficient irrigation water despite being a member of a water user group. The reason for this is local water conflicts in Dadeldhura, as a more upstream located village withdraws water, leaving less water for the more downstream located village we surveyed.

The unfair diversion of water was reported by 49 % in Doti, and in Dadeldhura it was slightly less (38.5 %), with twice as many missing responses (78 households did not respond) than in Doti. Regarding the diversion of water, the irrigation committee in Doti arranged one responsible person per tole along the canal who would manage the order of irrigating with the other toles. However, the diversion of water beyond the main channel was seen as unfair, as those fields located close to the outlet would receive most of the water, while fields located lower and further away would receive insufficient irrigation water. In these cases, water drinking taps were used for irrigation by connecting them to irrigation pipes. This would happen at night, so that neighbors would not see that they were using water meant for domestic purposes for irrigating their fields. This has resulted in many neighborhood quarrels, which were reported to us repeatedly during two different visits to the sites.

(4) Conflict management

We also assessed *conflict management* based on cooperation and knowledge sharing, satisfaction and trust in irrigation systems in both districts. While 92.3 % are satisfied with the cooperation among the group members, only 2.3 % (1 respondent in Doti, and 5 in Dadeldhura) stated being dissatisfied, and the remaining 5.4 % did not respond. Sixty-eight-point-six percent stated sharing water-related information with others in the village. Conflicts or fighting among group members was not stated by 89.6 % of all respondents, but a few (5.8 %) in Doti reported minor conflicts, and 2.7 % (4 households) reported major conflicts, whereas in Dadeldhura, one household reported minor, and 3 households reported major conflicts. However, unfair diversion of water was reported by 43.8 % overall, whereas more than half of the respondents had not reported this. If reported, the households reported unfair diversion "a lot" in Dadeldhura (32.1 %), whereas in Doti, both "a bit" (20.1 %) and "a lot" (28.9 %) were reported. Overall, only 7 respondents, 2.7 %, reported not trusting their group members, whereas the great majority reflected a great degree of trust (78.3 %), and 14.3 % reporting some degree of trust.

Further rule enforcement is needed as overall 73.4 % stated reporting theft of irrigation infrastructure, and 78.4 % stated reporting damages and water leakages along the irrigation infrastructure.

## 6. Discussion

Our results challenge the generalizability of widespread assumptions of deteriorating community-based resource management systems, which some case studies of irrigation systems have proved (Cox, 2014; Wang et al., 2016), and expand debates on the "loss of labor" in rural areas and the "deagrarianisation" due to rural out-migration (Hebinck, 2018; Ojha et al., 2017; Rigg, 2006). It is important to note that rural out-migration, rather than being a single driver of change, is among several socio-economic and political changes within agriculture and irrigation, and is mediated by local level power relations and intersectional inequalities regarding landownership, class, caste, gender and age.

In our study sites, there has been no "visible" decrease in collective resource management due to migration. Similarly, collective labor in irrigation canal maintenance has not been affected as sufficient labor is available in households and villages. However, labor inputs are increasingly provided by women and the elderly rather than (young) men. Similarly, financial contributions at household level are mostly functional. Regarding water user group meetings, an absent migrant in their household has opened up opportunities for women to participate. Due to broader social change, it has been more widely seen that women are speaking up in committees and groups. However, the composition of irrigation committees did not change because of rural out-migration, and existing leaders (elderly, mostly male Chhetris) have been in positions for a long time. Studies have shown that at the policy and implementation level, irrigation is considered a man's job and a masculine sector (Shrestha & Clement, 2019a). Against the background of high male out-migration and women's increased labor in irrigation, further research is required on "how women could play a role in framing and influencing water user groups to frame irrigation management rules and regulations in favor of greater participation of women", citing the Patron of the NGO Farmer Managed Irrigation System Trust (FMIST). At the same time, studies showed the importance of thinking of ways to include migrants in water management decision-making, and that"cultivating space for migrant self-organization could enable the agricultural community to be more resilient" (Erwin et al., 2022).

Hence, our results indicate that the farmer managed irrigation systems we studied are not affected by rural out-migration – rather the opposite took place: our study demonstrates a significantly higher participation rate in a water user group or irrigation committee in Far Western Nepal if there has been a migrant in the household in the past five years. This accords with the recent study by Meinzen-Dick et al. (2022) which demonstrated that women's attendance and speaking in water user group meetings is higher in sites with male migration and that rural out-migration is linked with low levels of land abandonment and labor shortages affecting irrigation systems. Our qualitative interviews explain the even higher participation in the absence of men as women need to meet the household's obligation or that women feel

[7] Irrigation projects were often incomplete due to lack of technical staff and transportation difficulties, according to one project staff member.

more responsibility to take action and to ensure their household's water and food security in the absence of men. Another finding is that they are more encouraged to join water user groups when more women are there in the first place. This result, however, must be seen against the background of ongoing debates of heavy workloads for women "left behind" (Gartaula, Visser, & Niehof, 2012; Meinzen-Dick et al., 2022). Furthermore, our intersectional perspective shows that some women are more burdened than others, especially due to care work and weak social networks, and, as Shrestha et al. (2023) show, due to caste/ethnicity, kinship, age and economic status.

While in our study a majority of households stated having decreased their crop yield, migrant households did not report a decrease in crop yield more often than non-migrant households. This finding opens up questions on currently widely accepted assumptions on the negative effects of rural out-migration on resource governance systems. Regarding labor contributions, such as unblocking irrigation canals or arranging water flows, our field observations and interviews demonstrate the greater involvement of women, which explains that the absent labor force due to migration is replaced by women.

These findings contrast studies such as by Popovici et al. (2021) which suggest out-sourcing water governance to intermediary and government institutions, as they found that farmers had limited ability to participate in local institutions for water management due to market integration and labor migration, among other socioeconomic and political stressors. Given the varied, contradictory impacts or rural out-migration effects on community-based resource management systems across regions, we hope that our study showed how to move from a binary understanding of migration effects to underlying social and gender relations, which shape rural out-migration effects. Similarly, the study by Qin and Flint (2012) has illustratively shown how the impacts of rural labor out-migration on community interaction varied, and that simplistic notions of migration as an unidirectional effect should be critically scrutinized. Our findings show that future studies should especially pay sufficient attention to the often invisibly rendered but important role of social and gender relations in community-based resource management systems in the context of rural out-migration (Leder, 2022, 2024). Furthermore, an intersectional approach including a detailed study of household structures and different regions can serve as explanations of various and contradictory effects of rural out-migration.

Our results demonstrate insightful differences between the districts of Doti and Dadeldhura regarding the occurrence and patterns of migration. The higher rural out-migration rates in Doti helped us compare differences in participation and the functionality of irrigation systems. However, we would like to note the limitations in our study and hence for the interpretation of our results, as well as the need for future research: Firstly, since the quantitative part of our study was a cross-sectional design, it does not allow us to see longitudinal changes over time. Secondly, the possibility of information bias exists. For some questions, long time frames (e.g. the last five years) were chosen. Nevertheless, throughout the qualitative interviews it was seen that the interviewees are able to recall changes in an acceptable way which minimizes the bias. Thirdly, we only compared the irrigation systems of two districts in the Far West of Nepal, thus our results can only exemplify and open up discussions on the important role of labor replacement within household units and the higher labor burden for women, which is often overlooked in much of the literature on the "loss of labor".

The way irrigation systems are managed depends not only on out-migration but also the overall policy of the government in relation to collective action. Nepal's Agriculture Development Strategy-ADS (Government of Nepal, 2015) and the Irrigation Master Plan (Government of Nepal, 2019) do not acknowledge the changing role of rural women in Nepali society. With male out-migration, women who previously were mere contributors to family agriculture have now become the primary farmer (Slavchevska, Doss, Mane, Kaaria, Kar, & Villa, 2020). Despite the change in their role, neither ADS or IMP takes into account the unique positions of female farmers to maximize their working capacities by supporting them in their care responsibilities through innovative approaches such as day care facilities for children. Women, despite the shift in their roles, continue subsistence farming with little or no aspiration for high value production or engagement in higher nodes of the value chain (ibid).

Furthermore, the ability to mobilize resources was not primarily a collective action concern, but a concern due to the decentralization efforts in Nepal which have re-arranged districts into 7 provinces with 753 local municipalities which are meant to improve access to irrigation funds. However, the new local municipalities lack human, technical and financial resources to revitalize irrigation systems. Particularly needed are gender-sensitive extension services, female officers, and targeted formats (e.g. time schedules adjusted to household chores and care work for children). Further concerns which remain to be addressed by policy makers are subsidies reaching women, especially by not requiring land ownership certificates, which usually hold the name of the male, as well as incentives to direct remittances towards water management, with measures developed in collaboration with local level governments.

The importance of local agriculture for food security has been particularly clear during the COVID-19 pandemic when migrant workers returned to their homes because of 'lockdowns' in their host countries.[8] Despite government plans to engage returnee-migrants in agricultural enterprises through agriculture input support and agriculture grants, the returnee migrants returned to their host countries when mobility restrictions were eased globally. This highlighted that the low agricultural productivity in Nepal is not solely related to the 'loss of laborers', but rather limited financial investment in farmer managed irrigation systems (Dhakal, Davidson, & Farquharson, 2018), limited outreach in extension services (Devkota, Thapa, & Dhungana, 2016; Leder, Shrestha, & Das, 2019; Leder, Das, Reckers, & Karki, 2016), as well as broader structural issues such as sectorial and technocratic government support (Shrestha & Clement, 2019b; Suhardiman, Clement, & Bharati, 2015). As Khatri, Nightingale, Ojha, Maskey, and Lama 'Tsumpa', P. N. (2022) put it in the case of the newly federalizing Nepal, the "mismatch between authority granted and institutional capabilities, in terms of opportunities to access and mobilize knowledge and financial resources", needs to be addressed.

Our results stress that it is important to go beyond the dominant discourse that blames rural out-migration for underperformance in the agricultural sector (Kim, Stites, Webb, Constas, & Maxwell, 2019; Pandey, 2021). Women-headed household have a higher risk of food insecurity, especially in remittance dependent families (Pandey, 2021). We suggest that agricultural policies and programs adequately acknowledge and address women as key actors in the agriculture and irrigation sector, and design action plans and targeted programs with the intent to support their capacities, and thereby address chronic food insecurity. It is equally important to identify strategies to encourage the investment of remittances in the agricultural and irrigation sectors.

[8] We do not have definite data on how the return of men affected their role in irrigation system management. Nevertheless, the data does indicate that men who returned were more interested in income-generating activities and hence approached the local government offices for agricultural subsidies. Returnee migrants who had savings opened small businesses. "My husband's hotel has become very famous in a short time in Tiltali. He is very happy with his success and he plans to stay back [in the village]", female respondent from Tiltali. Research participants in Tiltali also reported the increase in number of kiosks in the locality as men were interested in engaging in income-generating activities. This indicates men trying to reinstate their position as 'breadwinner' of the family. Therefore, despite no direct effect on the irrigation system, it will be valid to infer that male out-migration has shifted some intrahousehold decision making dynamics, but a fundamental shift in gender power dynamics is still a distant goal.

## 7. Conclusion

Our results challenge widespread assumptions of degenerating irrigation systems and debates on deagrarianization due to rural out-migration. Rather than a "loss of labor" (Ojha et al., 2017; Rigg, 2006), we note that labor contributions are mediated at the household unit, which results in women increasingly being involved with and sustaining irrigation systems. We also found that participation in a water user group or irrigation committee is significantly higher if there has been a migrant in the household in the past five years. We suspect that women feel a greater responsibility to ensure their household's water and food security, or are more willing to join water user groups when more women are there. These results may be different in more remote mountainous areas of Western Nepal or more broadly, which requires further research.

The study underscores the transformative potential of male out-migration with women taking over the labor previously deemed as 'masculine' (Leder, 2022). The study, however, shows a gap between labor being done and the recognition for the work – as all water user groups that we interviewed did not report changes in the governance committees. It implies 'invisibilization' of women's work. Understanding these hidden ground realities is important for designing effective policies and programs. The need to highlight women's increasing role in agriculture in general, and in the irrigation sector in particular, in the context of male out-migration, is also supported by the findings of the study by Goodrich, Udas, and Larrington-Spencer (2019) which shows the importance of reforming policies and redesigning programs towards more gender-sensitive investments.

Contemporary Nepali society does not have an economically viable alternative to offer rural men apart from foreign migration. Hence, remittances will remain an important contributor to household livelihoods and the GDP. The policies and programs (like ADS and IMP) do not align with the realities of rural Nepal as half of the working population are missing. The other half – mostly women – already bear the disproportionate brunt of care responsibilities. To achieve their aspirations of food security, both agricultural and irrigation policy should be revised to readjust their focus on alleviating women's limitation in leading domestic agricultural and irrigation projects.

With our analysis, we expand on current studies on migration effects on rural societies, which focus primarily on measurable demographic changes and economic outcomes. We open up debates on the mediating role of gender and social relations in community-based natural resource governance, which play an increasingly important role in collective irrigation management. Future research shall seek to identify the pathways through which the greater engagement of women and marginal groups can help to revitalize collective natural resource management. Such bottom-up processes of change could be a vital part of a long-term transition towards more equal access to resources and improved food security in rural households of the Global South.

## CRediT authorship contribution statement

**Stephanie Leder:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - original draft, and Writing - review & editing. **Rachana Upadhyaya:** Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Writing - original draft, and Writing - review & editing. **Kees van der Geest:** Conceptualization, Formal analysis, Methodology, Writing - original draft, and Writing - review & editing. **Yuvika Adhikari:** Formal analysis, Methodology, Project administration, Supervision. **Matthias Büttner:** Conceptualization, Data curation, Formal analysis, Methodology, Software, Validation, Visualization, Writing - original draft, and Writing - review & editing.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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