Examining the Water-Energy-Food Security-Ecosystem Nexus Approach in Nepal

Learning from Some Case Studies

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Disclaimer

Foreword

The Water-Energy-Food-Ecosystem (WEFE) nexus approach has gained popularity recently because the security of natural resources is fundamental to human welfare. The WEFE nexus approach helps maximize synergy across water, energy, food, tenure, and livelihood security while minimizing trade-offs, particularly in terms of environmental damage, social costs, and economic losses. This approach centers on ensuring gender equality and social inclusion (GESI) in managing natural resources.

The WEFE nexus refers to the connections between four resource sectors: water, energy, food, and ecosystems. It involves the synergies, conflicts, and trade-offs that arise from how these resources are managed. The approach rejects isolated management practices and single-sector policies that lead to sectoral silos and non-sustainable practices. It aims to foster stakeholder integration and considers multiple solutions to create synergies among various sectors. By addressing both benefits and trade-offs comprehensively, the WEFE nexus approach seeks to avoid short-term solutions and instead promote long-term sustainability. It emphasizes the importance of managing resources in a coordinated and integrated manner to ensure the overall well-being of ecosystems and human societies.

Despite its strong theoretical foundation, the WEFE nexus has been criticized for lacking adequate practical examples and case studies. Specifically, in Nepal, the approach is relatively new, with no documented cases or dedicated projects designed with the WEFE nexus approach in mind. Therefore, despite its theoretical popularity, it remains in its infancy regarding its conceptualization and application at policy, institutional, and local levels.

To fill this gap, GREAT International, together with Governance Lab, has made a small attempt by inviting a group of researchers–namely Anita Shrestha, Anushiya Shrestha, Dinesh Bhuju, Gauri Shankar Bhandari, Kaustubh Thapa, Kushal Pokharel, Meena Bohara, Parshuram Niraula, Robindra Roy, Sagar Dhakal, and Sailesh Ranjitkar–to document several case studies in a short period with limited technical and financial resources. These case studies cover various themes, including community forestry, bio-energy, agro-forestry, agriculture and farming systems, nexus governance, protected area management, groundwater treatment systems, and more, to show the connections between various natural resource sectors in different configurations. While of all these case studies may not necessarily cover all key elements of a WEFE nexus approach, they provide an important opportunity to readers to critically review the cases and examine them in the context of opportunities and challenges they present in the application of the WEFE nexus approach. This is the key value addition of this compendium of case studies.

Special thanks also go to Binod Chapagain, Karuna Onta, Nisha Onta, and Meeta Sainju Pradhan, who reviewed the case studies. I would like to acknowledge the contributions of all the authors and their respective organizations. This effort would not have been possible without the financial and technical support of IWMI and ABC. I hope these case studies will be useful to those interested in the WEFE nexus approach and mainstreaming GESI in managing natural resources at the policy, institutional and local levels.

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Emerging Possibilities Amidst Persisting Boundaries: Strengthening WEFE Nexus Governance in the Federal Governance System of Nepal

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Abstract

This case study delves into the potential for advancing Water, Energy, Food, and Ecosystem (WEFE) nexus governance within Nepal's federal structure, with a specific focus on policy and institutional dimensions. Centering on the water sector, the article explores the emerging opportunities for championing a nexus approach in the federal governance system despite prevailing policy and institutional hurdles. Leveraging insights from institutional mapping and analysis as part of a broader study on WEFE Nexus Governance in Federal Nepal, the article offers empirical insights from interviews and discussions with key stakeholders spanning both state and non-state sectors engaged in WEFE governance.

Policy and Institutional Context of WEFE Nexus Governance

Nepal's transition from a unitary to a federal setup is marked by a collective vision and acknowledgement of the significance of an integrated and systemic approach to managing and utilizing WEFE resources. The Constitution of Nepal (2015) delineates provisions for integrated natural resource management and governance, with a particular emphasis on the Directive Principle, Policy and Obligation of State (Part-II). This underscores the necessity of a distinct policy aimed at conserving, promoting and utilizing natural resources in an integrated manner. Various intergovernmental bodies, such as the Interprovincial Council, Provincial Coordination Council, National Coordination Committee and Sectoral Committees, have been instituted to operationalize this integrated approach. Furthermore, the constitution's schedules highlight a multi-sectoral focus by enlisting natural resource rights, including electricity, drinking water and irrigation as integrated sectors. However, despite these structural mechanisms, their effectiveness remains limited. For instance, the Interprovincial Council (IPC) has not convened a single meeting in the past four years, and its mandate to draft critical laws related to education, tourism and agriculture by April 2019 remains unfulfilled (Devkota, 2023).

Proponents of the nexus approach in the WEFE sectors advocate for a comprehensive multi-level assessment of existing institutional arrangements. This assessment helps to identify existing convergences and institutional innovations that enable integrated resource management and reduce the trade-offs across the sectors (Ringler et al., 2013. The role of a nexus approach in fostering an inclusive approach conducive to the well-being of the poor and marginalized has been well documented (ibid). Against this theoretical backdrop, Nepal's recent efforts towards integrated resource management have focused on collaboration and synergy, although the term 'nexus' has not been explicitly mentioned in any of the policies and program documents. Nevertheless, the nexus approach can be an important entry point toward translating the policies aiming for integrated and inclusive resource management.

In the context of the water sector, the 2015 Constitution of Nepal has embraced an integrated approach to water resource utilization, management and conservation, prioritizing national investment in water resources based on people's participation and a multi-utility development of water. Although the calculation of trade-offs hasn't been duly considered, the Constitution has incorporated elements of creating synergies related to managing WEFE resources. Schedules 5-9 of the constitution have distributed the role of water resource management among the three levels of government. The federal government is mandated to define the overall national water resources policy directions and undertake the development of central-level large water projects, including negotiations for transboundary issues and inter-provincial research and development. Meanwhile, the roles of provincial and local governments include water supply and sanitation, irrigation, electricity services and watershed protection activities within their respective jurisdictions. Furthermore, constitutional policy provisions also envision a sustainable and reliable irrigation system mitigating water-related natural disasters and managing the river systems.

The National Water Resource Policy (NWRP) 2020 has reverted to an integrated approach, aligning with the earlier Water Resources Strategy Nepal, 2002 (see WECS, 2002). Prioritizing integrated water resources management, the NWRP (2020) adopts a basin approach to facilitate the multi-purpose use of water through multisectoral coordination and collaboration (MoEWRI, 2020). The establishment of multi-sectoral ministries and institutions at the federal and provincial levels, along with the devolution of roles and resources for local natural resource management to local governments, provides opportunities for cross-sectoral and cross-scalar interactions and actions. Within the Ministry of Forest and Environment (MoFE), the forest and watershed division has embraced a multisectoral approach in the forest, soil and water nexus, focusing on soil conservation and watershed management through dedicated sections such as watershed and soil conservation.

Additionally, the government has recently proposed a sub-basin approach through 23 offices in all provinces under the "Science, Environment and Watershed Division" for integrated watershed management (Paudel et al., 2019, p. 74). Moreover, international and national research institutions have advocated for a multi-sectoral integrated approach to water management. There is a growing interest among federations of drinking water and

irrigation, forests and food, to collaborate on issues of public welfare (for more details, see section 2).

Similarly, sectoral policies such as those concerning water, demonstrate progress in terms of including women and other disadvantaged groups in formal water user committees, associations and decision-making processes (HMGN, 2002; HMGN, 2005; HMGN/MoPPW, 2004; GoN/MoPPW, 2009 GoN, 2013). Numerous federal-level ministries, including those relating to agriculture (MoALD), forestry (MoFE), federal affairs and general administration (MoFAGA), have devised sectoral Gender Equality and Social Inclusion (GESI) strategies (for example, see GoN /MoALD, 2021) and established GESI units to promote an inclusive approach to resource management. Provincial ministries and local governments are also formulating GESI strategies to mainstream GESI and facilitate targeted interventions.

Nevertheless, institutionalizing GESI practices remains challenging (ADB et al., 2012). Opportunities for women to hold leadership and decision-making positions are still limited (DWRI, 2019; Shrestha and Clement, 2019). As noted by Khadka et al. (2021), the evolving water policies in the federal context tend to favor large infrastructures, lacking the policy impetus needed to ensure equitable, inclusive and sustainable water management for multiple water uses and improved water governance.

In summary, the prevalence of political interests and ongoing disputes over resource allocation and budget distribution have constrained the capacity of WEFE institutions to facilitate meaningful dialogues geared towards policy-level cooperation and coordination among the three levels of government (Suhardiman et al. 2015; Khatri et al. 2022).

Policy Practice Gaps: A Persisting Challenge

Despite the reallocation of resources and authorities, persistent overlapping roles and responsibilities among the federal, provincial and local governments, and limited capacity and resources to function effectively with the federal setup (The Asia Foundation, 2017) remain obstacles to WEFE nexus initiatives. For example, while the constitution assigns the provision of drinking water services to the exclusive jurisdiction of local governments and concurrently to the federal, provincial and local governments, efforts to prevent project duplication have been ineffective, leading to simultaneous implementation of similar projects across all three levels of government (DRCN, 2020).

At the institutional level, the existence of numerous ministries, departments and divisions at the federal level with limited nexus platforms for fostering deliberations on integrated natural resource management impedes the realization of nexus gains. While some intersectoral ministries and line institutions, such as the Ministry of Water Supply, Irrigation and Energy, Ministry of Agriculture, Energy and Water Resources, have been established at the provincial level, there remains a larger disconnect with local governments. More importantly, sectoral priorities in formulating development programs and budget allocations pose obstacles to enhancing coordination and integration efforts among ministries and departments relating to WEFE.

Another dimension of the policy-practice gap also relates to the attitudes and beliefs held by WEFE actors and institutions. Some operating actors and institutions find it actually demotivating to pursue a nexus approach in WEFE governance, perceiving it as a threat to their existing authority and power. In a roundtable discussion, a representative from a hydropower company expressed reservations about the formation of the multi-sectoral Ministry of Energy, Water Resources and Irrigation (MoEWRI): *"Adding irrigation to the Energy Ministry has increased burden and disincentivized the private sector interested in the development of the energy sector. The government needs to clarify its priority between the development opportunities from the energy and irrigation sector" (Interview note, Nov 27, 2022).*

Likewise, in a panel discussion focused on the challenges and prospects of solar-pumped irrigation, the delegate from the Alternative Energy Promotion Centre (AEPC) remarked that Nepal Electricity Authority (NEA)'s reluctance has discouraged APEC from promoting solar-pumped irrigation. Declining interest and the lack of strong implementation mechanisms for promoting synergy and coordination across energy and irrigation sectors are among the major challenges in realizing nexus gains (Panel discussion, March 17, 2023).

Another dimension of the gap relates to the lack of appropriate institutional arrangements to translate policy into practice. An expert involved in formulating the NWRP, 2020 shared that in the absence of an umbrella act and other legal provisions to operationalize policy, the goal of integrated water resource management hasn't been realized (Interview Notes, 2022). Overlapping institutional responsibilities and lack of coordination and clarity in roles within and between water-related ministries, departments and offices hinder intersectoral approaches in the water sector. A representative from a civil society organization (CSO) shared: *"MoEWRI has more interactions with forest, agriculture and other ministries compared to the Ministry of Water Supply (MoWS) which works in the water sector (Interview note, CSO representative, Oct 2022).*

The policy-practice gap is also evident in GESI efforts within the WEFE sector. Grassroots organizations and their federations pointed to the representation of women in formal water user committees and women-focused events as indicators of progress in GESI within the water sector. For instance, the National Federation of Irrigation Water Users Association, Nepal (NFIWUAN) has ensured 33% representation of women, Dalits, Janajatis, and socio-economically marginalized and disadvantaged groups in its decision-making structure (Interview Note, October 11, 2022). A more progressive approach is observed in the Federation of Drinking Water Users' Nepal (FEDWASUN), which mandates 50% representation and currently includes two Dalit women, Madhesi and Janajatis in its central committees (Interview note, September 2022).

Studies, however, suggest that the integration of marginalized communities, including women and Dalits, among others, has been largely symbolic, failing to facilitate meaningful participation of these groups in natural resource management planning and decision-making at both national and sub-national levels (Wali et al., 2020; Udas and Zwarteveen, 2010). Women representation in leadership positions within farmers' organizations, cooperatives or extension services, continues to be limited due to entrenched patriarchal

values and norms, limited institutional and family support, and inadequate formal education and security (Bhattarai, 2020; Singh et al., 2020; Upadhya and Shrestha, 2021).

A female representative of the NFIUWAN shared, "Until five years back, I was the only female chairperson of the irrigation water users' association. We now have about seven female representatives in the central federation, and I hope this will increase in the upcoming district and national level congress". However, she pointed out, *"Women still lack the capacity and the confidence to voice their concerns and influence the decisions. I share my experiences and encourage them to take up leadership roles. Ultimately, it is us, the women, who perform the bulk of the farm work" (Interview Note, Nov 18, 2022).*

Adopting a WEFE Nexus for Advancing an Inclusive and Integrated Approach: Experiences, Insights, and Scope in Federal Nepal

Expanding nexus gains is feasible at both policy and institutional levels. The National Water Resources Development Council (NWRDC), chaired by the Prime Minister, serves as the apex decision-making authority on national water resource management. It possesses the authority to issue directives and oversee the sustainable development of water resources, ensuring coordination among various sectors at the federal, provincial, district, and municipal levels (Winrock, 2021).

Some initiatives, such as the Multi-stakeholder Forestry Program (MSFP) and REDD+, have aimed to adopt an inclusive and integrated approach to managing water, energy, food and forest resources in Nepal. While efforts have been made to advance WEFE sector agendas through networks like the Confederation of Natural Resources, progress has been hindered by parochial sectoral interests. Nonetheless, there is increasing recognition of the importance of cross-sectoral coordination and collaboration. Given the interconnectedness and interdependencies of WEFE resources, there is value in drawing lessons from past and ongoing multi-sectoral initiatives. Interestingly, some projects, like the Rural Village Water Resources Management Project (see Box 1 below), have embraced a multi-sectoral approach to local water resource management.

The establishment of multisectoral ministries and institutions at both federal and provincial levels, along with the expanded roles of local governments in holistic development, has created opportunities for synergy and collaboration. Ministries such as the Ministry of Energy, Water Resources and Irrigation at the federal level, and similar bodies like the Ministry of Water Resource and Energy Development (Karnali), and Ministry of Energy, Water Resources and Water Supply (Gandaki) at the provincial level, exemplify this trend. Additionally, the creation of institutions like the Agriculture Knowledge Center, Irrigation Divisions, Soil and Watershed Management Offices at the provincial government, along with the Division Forest Offices, have paved the way for coordinating and implementing various programs at the sub-national level.

However, overcoming entrenched sectoral silos and technocratic dominance within and beyond the water management domain remains crucial for effective institutional integration. The newly created Water Resource Research and Development Centre (WRRDC) under the

MoEWRI is an example. Although created as a unit for research and development in the water sector, its objectives display bias towards the irrigation sector and technocratic research. Capacitating such institutions to operate as multi-sectoral and transdisciplinary research and capacity-building units, can enhance their roles and contributions in the multi-purpose development of water resources and help bridge existing gaps between the social and technical components of water management.

Another crucial opportunity exists in sensitizing and strengthening local governments which are at the frontline of delivering equitable, sustainable and resilient water (and other) services. Revitalizing the District Coordination Committee, positioned at the center of vertical coordination among local, provincial and federal governments, as well as horizontal coordination across local governments, can be instrumental in promoting nexus dialogues and exchanges. This can foster much-needed cross-sectoral and cross-scalar coordination between government and non-government actors. Piloting the WEFE nexus approach in local governance decision-making and development practices can provide useful lessons for upscaling and outscaling the WEFE nexus approach. Without implementation, there is a risk that the nexus approach may remain a normative concept that is fashionable but weak in execution.

Box 1: Rural Village Water Resources Management Project, Phase III (RVWRMP III)

The RVWRMP III is a multilateral project funded by the Government of Nepal, the European Union, and the Government of Finland in collaboration with the local government and communities. Its primary objective is to facilitate the development of Water Use Master Plans for rural municipalities and implement drinking water supply schemes. Moreover, it aims to strengthen the capacity of local cooperatives, offer technical assistance, and support irrigation to enhance the agribusiness-based economy. Other initiatives under RVWRMP include the construction of schools, health centers and public toilets, alongside efforts to raise awareness of disaster and climate change issues. The project also promotes the installation of solar mini-grids, improved cooking stoves and water mills, while strengthening the institutional capacity of local governments and non-governmental organizations.

Drawing lessons from previous integrated development projects, both within and beyond the water sector, can provide invaluable insights into identifying key areas for scaling up locally driven, practical and progressive measures. These insights are essential for institutionalizing and maintaining cross-sectoral coordination and collaborative efforts essential for achieving integrated and inclusive development.

Table 1: Opportunities for WEFE nexus governance in the federal context (with water as the entry point)

Multi-sectoral policies, programs and strategies	Cross-sectoral Institutions and initiatives	Changing attitudes and behaviors
National Water Resource Policy, 2022	MoEWRI, Water and Energy Commission Secretariat (WECS), watershed, climate change units in MoFE, WRRDC, Intersectoral provincial ministries, Local governments	Growing interest among WEFE federations and user associations to collaborate in an integrated manner to promote sustainable livelihoods.
National Water Resource Strategy, 2002 National Adaptation Programme of Action to Climate change adopted community-based adaptation through integrated development of agriculture, water, forest and biodiversity sector.	Natural Resource Confederation (loose informal network) of WEFE federations	Growing discussions and deliberations on promoting nexus governance being facilitated by international non-state actors, with support from national, provincial level WEFE ministries and departments
River basin strategy (for e.g., Water resource development strategy for Kamala River basin, 2021)	National coordination and sectoral committees, Interprovincial Council, Provincial Coordination Council as provisioned in the constitution; sub-basin offices, District Coordination Committee at the local level	Devolution of authority at the sub-national level with an enhanced autonomy leading to provincial and local governments
	President Chure-Tarai Madhesh Conservation Development Board (PCTCDB), River basin initiatives (e. g. Koshi Basin Initiative)	Gradual inclination towards system thinking approach at policy and institutional level (national adaptation plan, climate change coordination council)

Way Forward

Given the policy and institutional context described earlier, several strategic interventions can be proposed to promote nexus thinking and practice:

» **Establish an overarching policy framework:** Develop a comprehensive policy framework designed to enhance multi-sectoral interactions and interlinkages. This framework should offer clear guidance to facilitate the transition from 'nexus thinking' to 'nexus doing'.

» **Activate intergovernmental bodies and mechanisms:** Revitalize intergovernmental bodies and mechanisms to facilitate coordination among federal and provincial governments, as well as between provincial and local governments. Prioritize cross-sectoral collaborations and inclusive management of natural resources within these structures.

» **Enhance administrative and technical capacities:** Strengthen the administrative and technical capacities of federal, provincial and local governments to facilitate integrated management and governance of WEFE resources. This involves investing in training programs and infrastructure to ensure the successful implementation of initiatives.

» **Advance gender-responsive approaches:** Incorporate gender-responsive principles across the planning, implementation and monitoring phases of integrated natural resource management initiatives. Ensure that policies and programs are designed to address the specific needs and priorities of women and other marginalized groups.

» **Strengthen formal GESI units and mechanisms:** Enhance the capacity and efficacy of formal GESI units and mechanisms. These entities should serve as the foundation for driving gender-balanced and socially inclusive management of natural resources nationwide.

» **Host multi-sectoral and multi-stakeholder consultations and dialogues:** Organize periodic multi-sectoral and multi-stakeholder consultations and dialogues facilitated by state institutions to promote nexus governance. These forums should provide a platform for discussing and promoting integrated approaches to resource management.

» **Support and sensitize local governments:** Provide support and awareness programs to local governments to enhance their capacity in WEFE resource management. Enable them to understand the socio-environmental ramifications of siloed approaches and opportunities for cross-sectoral collaboration and cooperation.

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A WEFE Nexus Approach: A Case Study of Forest Fires in Manthali Municipality, Ramechhap, Nepal

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Introduction

Forest fires pose significant ecological and socio-economic challenges in Nepal, with adverse impacts on biodiversity and livelihoods. The frequency of forest fires is escalating annually, (Elagib, 2020). These fires are driven by factors like climate variability, human activities and forest composition. Given Nepal's diverse topography, it ranks among the susceptible countries to forest fires (Koirala, 2014). Hence, forest fires are of national interest and are intricately tied to development agendas. Rising temperatures, prolonged droughts and erratic rainfall patterns exacerbate the severity of forest fires in Nepal. The risk of forest fire further increases by the accumulation of combustible materials in poorly managed forests (Pandey, 2022). Despite their national significance, forest fire management in Nepal suffers from a lack of cohesion between national policies, district level institutions and local practices, hindering mitigation efforts.

In Manthali Municipality of Ramechhap district, forest fires often receive limited attention, especially as they mainly occur outside private properties. The capacity within relevant agencies to effectively address forest fires is constrained. Despite the guidance provided by the Forest Fire Management Strategy 2010 for plan preparation and wildfire prevention, continuous investment from the national budget, and efforts from community forest user groups in Manthali-2, the incidence of forest fire is increasing (Nepal, 2021). Climate-induced droughts are worsening in severity in Manthali of Ramechhap district (Joshi, 2018), which likely is contributing to the rise in forest fire incidents. During the forest fire of 2010 AD, the army attempted to control the blaze in Ramechhap Municipality-2, albeit unsuccessfully, resulting in the tragic loss of 13 Nepal Army personnel.

The water-energy-food-ecosystem (WEFE) nexus presents various benefits to Manthali Municipality in effectively managing forest fires which directly impact communities and contribute to improving their livelihoods.

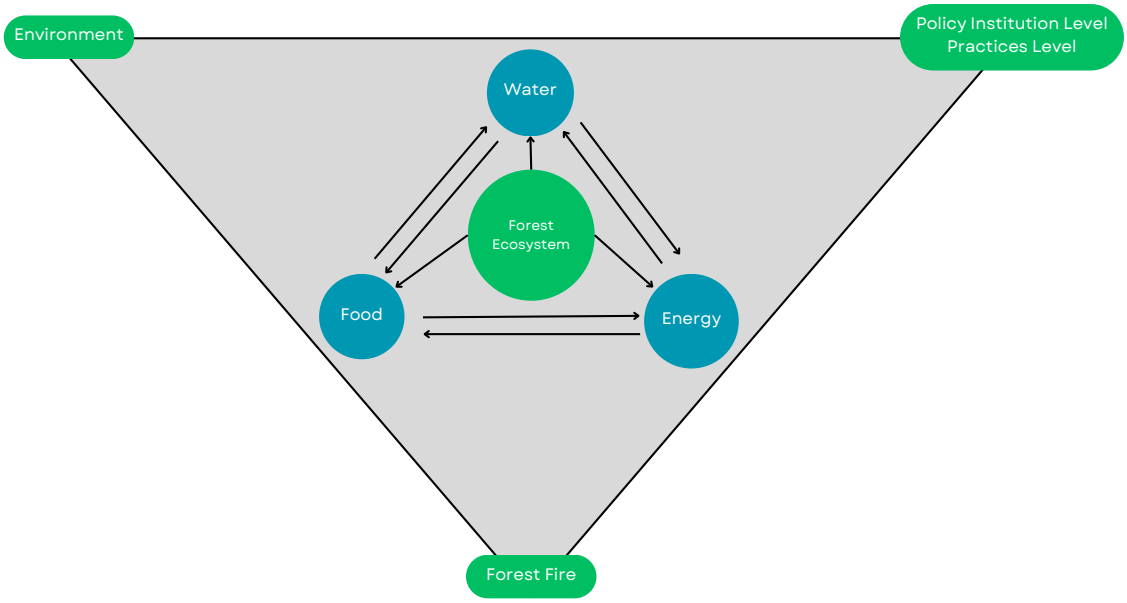

Figure 1. A conceptual framework illustrating the WEFE Nexus approach with forest fire.

For this case study, we conducted field surveys and key informant interviews to investigate forest fire management practices in Manthali Municipality. Our hypothesis suggests that adopting the WEFE nexus approach is crucial for effectively managing forest fires in Manthali Municipality in Ramechhap district.

The WEFE framework emphasizes the interdependencies and interconnections between water, energy, food and ecosystems (Figure 1). It acknowledges that actions within one domain can significantly impact others, emphasizing the need for a holistic approach to addressing challenges related to these resources.

2. Methodology

2.1 Study Area

The study was conducted in Manthali Municipality in Ramechhap district, known as one of the most drought-affected regions in Nepal.

2.2 Methods of data collection

The case study employed a combination of methods, including a preparatory literature review, field observations and stakeholder interviews. Stakeholders interviewed comprised members of community forest user groups (n=3), officials from various governmental offices including the Division Forest Office (n=1) and Manthali Municipality (n=2), as well as local residents (n=2).

3. Findings

In Manthali Municipality, gathering wild food from forests, such as wild edible mushrooms, fodder, medicinal plants and timber, was a common practice, particularly in periods when conventional agricultural crops were unavailable before 1980 A.D. However, in recent times, forest fires have significantly impacted the biodiversity in the area.

A former Chairperson of Dumri Kharka Community Forest User Group (CFUG) in Manthali-2, Ramechhap, served as the president of the Dumri Kharka CFUG for 25 years. At 83 years old, the former Chairperson emphasized the pivotal role of forests in providing a diverse range of healthy foods high in micronutrients and fiber. Forest products carry immense cultural significance and are integral to local food systems, bolstering food security by bridging seasonal and cyclical food gaps and serving as a safety net during periods of drought, crop failure, illness, or other emergencies. He stressed the critical importance of biological diversity in agriculture and forestry systems, highlighting its relevance to pharmaceuticals, aesthetics, recreation and spiritual value, ecosystem stabilization, environmental quality, and the intrinsic value of all species on Earth. He also voiced concern over forest fires as a major threat to the forest ecosystem. The former Chairperson along with family members actively engages in awareness programs and community discussions on forest fire risk mitigation and biodiversity conservation.

The Division Forest Office (DFO) in Ramechhap district has implemented several projects aimed at conserving all types of forests including community forest, private forest and government forests, with the primary goals of forest fire prevention and control.

A Divisional Forest Officer from Ramechhap shared insights on the importance of adopting a WEFE nexus approach to effectively manage forest fires. The Officer underscored the need for a holistic framework that acknowledges the interconnections among various governmental institutions. He stressed the importance of coordinated efforts involving relevant government institutions, community groups, volunteer groups, and non-governmental organizations to effectively combat forest fires. However, the Officer commented that a lack of cohesive nexus between these entities at the policy level, coupled with communication and action gaps, has resulted in disjointed operations and diminished effectiveness due to inadequate coordination. He emphasized that the WEFE nexus approach is not only applicable to forest fire management but also extends to areas such as water conservation, food security, energy conservation, and ecosystem preservation. Thus, he asserted that the WEFE nexus is pivotal for both local development initiatives and the conservation of forest ecosystems. The Officer concluded by recommending the incorporation of the WEFE nexus approach into forest fire management discussions at local, institutional, and policy levels. He suggested that at the local level, conducting workshops and engaging stakeholders are important to understand the impact on water, energy, food, and ecosystems. At the institutional level, forming cross-sectoral teams, promoting interdisciplinary research, and allocating funding for WEFE-integrated projects are useful. Similarly, at the policy level, developing holistic policies, advocating for WEFE approaches, and establishing monitoring and reporting mechanisms are important to ensure comprehensive forest fire management.

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The fire line in the forest serves as a crucial barrier in containing the spread of forest fires.

Figure 2. A fire line broke out in the massive forest fire at the Badipakha Community Forest in Ramechhap District. Source : https://kathmandupost.com/national/2018/02/08

Lawa Shrestha, the Chairperson of Manthali Municipality, recounted an incident involving a large-scale fire outbreak at the Badipakha Community Forest in Ramechhap (figure 2). This fire posed a grave threat to the District Hospital. In response, all stakeholders in the district including the Division Forest Office, Nepal Army, District Disaster Management Team, forest user groups and locals were mobilized. Furthermore, a fire engine from Manthali Municipality was strategically stationed at the hospital premises to protect the healthcare facility from potential fire damage.

The coordinated response of all district institutions, Manthali Municipality, community forest user groups and residents, alongside the efforts of the fire department, played a crucial role in containing the forest fire and minimizing further damage. Table 1 illustrates the WEFE Nexus approach at various levels in forest fire incidents in the study area.

Table 1: WEFE Nexus approach in forest fire incidents in Ramechhap.

Case Components	Nexus	Results	Remarks
Policy Level (PL)	Various disaster management policies including Forest Fire Management Strategy 2010 and the National Disaster Risk Reduction Policy 2075, lack interconnectedness and coordination.	No established nexus for forest fire management	Gap in nexus at the policy level
Institutional Level (IL)	Government Institutions and other stakeholders operate independently for disaster management	No coordination among government Institutions and other stakeholders at the implementation level	No nexus in the preparedness plan
Local/Practices Level (L/PL)	Social connection exists	No ownership and responsibility	Ad *hoc* basis

There are knowledge gaps due to the lack of a conceptual framework and practices to interlink forest fire drivers with the water-energy-food nexus and related ecosystem processes (Martin, 2016). Forest fires act as drivers of changing flora and fauna; landscape changes are interlinked with life cycles in water, energy, food, and other key elements in ecosystem processes. Furthermore, forest fires present critical challenges by causing

increased loss of vegetation, reduction in food sources, and degradation of water recharge areas, thereby resulting in changes in water, energy and food dynamics, as well as ecosystem processes at regional scales (Zhang, 2022). Thus, forest fire changes the ecosystem services provided by forests for life support, goods and natural resources from water, energy, and food, as well as the environment. The heightened incidence of forest fires, changes in forest composition and landscape, and increased water stresses from drought can diminish ecosystem services, impacting the water and energy nexus and agricultural food production, and wildlife habitats on a regional scale. Integrated management of water, energy, food and related ecosystem processes at policy, institutional and practice levels is essential for adapting to and mitigating the impacts of forest fires in the study areas. Scientific research and policy support are crucial for addressing knowledge gaps in the WEFE nexus and forest fires and understanding the complexity of ecosystem services in the study area.

Elements of Synergy among Forest Fire (as part of Ecosystem) and its Impact to Water (Soil Moisture) and CO_2 Emission

Forest fires, integral to many ecosystems, intricately interact with energy, water and carbon dioxide (CO2) dynamics. The energy component of forest fires involves the release of stored chemical energy within vegetation, primarily in the form of plant biomass. When ignited, this energy is released through combustion, producing heat and light. This heat accelerates the evaporation of water from the soil and vegetation, leading to a decrease in soil moisture and vegetation cover. Consequently, this poses challenges for water retention and availability in the affected areas. Additionally, the reduction in vegetation cover diminishes shade, resulting in heightened surface temperatures and increased rates of evaporation. These alterations in soil moisture can trigger cascading impacts on local hydrological cycles, potentially modifying runoff patterns and increasing susceptibility to erosion.

Forest fires are significant sources of carbon dioxide emissions, releasing substantial amounts of CO2 into the atmosphere through the combustion of organic matter. This process temporarily elevates atmospheric CO2 levels. While forest fires are a natural component of the carbon cycle, recurrent or severe fires can disrupt this balance, potentially causing a net rise in atmospheric CO2 concentrations. Moreover, the depletion of vegetation diminishes the ecosystem's capacity to sequester carbon, exacerbating the overall carbon balance.

Hence, recognizing the interconnections among forest fires, carbon emissions and soil moisture content is pivotal for devising fire prevention strategies aimed at preserving the intricate balance of energy, water and carbon within forested ecosystems. This understanding is essential for fostering ecological resilience and long-term sustainability.

Based on this insight, it is crucial to implement comprehensive forest management practices that include controlled burns, firebreak creation, water retention strategies like

building ponds, reforestation efforts, and soil moisture monitoring. Policymakers should also develop regulations that limit activities contributing to deforestation and promote the use of technology for early detection of fire risks. By taking these actions, we can mitigate the adverse effects of forest fires, reduce carbon emissions, and enhance the overall health of forest ecosystems.

Elements of GESI – Livelihoods Affected by Forest Fire

When considering the impact of forest fires on the livelihoods of marginalized groups such as women, Dalits, and poor farmers without forested land, a number of gender, equality, and social inclusion (GESI) elements become relevant.

a. Gender Considerations:

Forest fires frequently disrupt the daily activities of women, who often play important roles in managing their household resources and are particularly vulnerable due to their responsibilities. This disruption affects essential tasks like collecting water, fuelwood, and fodder, which are essential for sustaining their households.

b. Social Inclusion (Dalits):

Dalits, who are often marginalized and vulnerable, face limited access to resources and encounter difficulties in coping with the aftermath of forest fires.

c. Poverty and Livelihoods:

Poor farmers, heavily reliant on agriculture, endure substantial economic losses due to damage caused by forest fires. Drought, coupled with the loss of fuelwood, timber, non-timber forest products, and fodder for livestock, exacerbates their impoverishment.

4. Conclusions

The discussion with the forest officer emphasized the Forest Service's crucial role in advocating to the public and policymakers about the value of forests and their contributions to the nation's economy, environment and society, as well as the importance of the WEFE approach in forest fire management. Beyond the forestry community, effective communication of this message is essential to garner support for sustainable management of forest fires.

In conclusion, this case study identified coordination gaps among policies, government institutions and practices for managing forest fires in the Manthali Municipality. The existing communication and action gap lead stakeholders, including various government institutions, community groups, volunteer groups and non-governmental organizations, to operate independently during forest fire incidents. To improve the efficiency of the

forest fire management practices in Manthali, implementing the WEFE approach is crucial. This approach can help overcome communication barriers and promote cross-sectoral collaboration, leading to more effective forest fire management.

5. Recommendations

To initiate a more integrated approach to managing the water-energy-food-ecosystem in Manthali Municipality areas, the following could be considered:

5.1. Policy Integration

The WEFE approach is for advancing sustainable development goals in Manthali Municipality. To strengthen this approach, it is crucial to leverage the recognition of forest management as a strategic measure within the Local Adaptation Plan for Actions (LAPA). Advocating for the explicit inclusion of the WEFE nexus in relevant policy documents will further support this effort. Additionally, involving local communities and community forest user groups in policy and development activities aligned with the WEFE approach for forest fire management can yield significant benefits.

5.2. Institutional Coordination

5.2.1. Connection between Organizations

Establishing clear policy guidelines is essential to facilitate the implementation of the WEFE approach by relevant district offices. Developing and implementing a WEFE approach guideline can significantly enhance sustainable natural resource management practices, particularly in forest fire management within Ramechhap district.

5.2.2. Research and Innovation

Allocating resources for research and innovation is essential to explore and document the nexus dynamics in forest fire control practices. This investment can empower communities to enhance their resilience to environmental change, improve institutional procedures and influence policy decisions effectively.

5.3. Practice Level

5.3.1. Community Engagement

The nexus practices observed within local communities, such as those in the Dumri Kharka Community Forest User Group should be acknowledged and reinforced. It is essential to formalize and strengthen these practices, fostering a mutually beneficial relationship between the community and relevant institutions. Facilitating dialogues

between community members and relevant stakeholders, including NGOs, INGOs and local governments, regarding the concept of the WEFE nexus approach could be a valuable strategy.

5.3.2. Awareness and Training

Awareness and training programs on the WEFE approach should be conducted for institutional authorities such as the Division Forest Office, Water Supply and Sanitation Division Office, Nepal Electricity Authority and Nepal Food Corporation. These programs will help establish linkage between the relevant implementation offices. Similarly, local beneficiaries and stakeholders, including community forest user groups and residents, can raise awareness through meetings, training sessions and awareness campaigns about the benefits of the nexus approach in controlling forest fires and enhancing ecosystem services.

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Nexus Governance in Manthali: Bridging Gaps and Shaping Homegrown Solutions

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Introduction

As a structural and functional unit of nature, the ecosystem sustains all human and non-human needs. Some scientific deliberations highlight the interconnected nature of our ecosystems, which sustain us, and propose a holistic approach to resource utilisation. However, the modernist approach to economic prosperity has treated this natural system in disintegrated forms under the so-called 'specialisation' (see Illich 1971; 1978; 1981 for criticisms of expertise). This became the hallmark of modernity, shaped by classical governance and policies, characterised by fragmentation and operating in silos, despite working for socio-economic development. Instead of more holistic socio-ecological well-being, the fragmented approaches for maximising profit, growth and development were prioritised globally, leading to various ongoing socio-ecological crises.

In contrast to siloed sectoral thinking, the Water, Energy, and Food Ecosystem (WEFE) nexus represents an attempt at a more holistic approach. This approach recognises the interrelated relationships between water, energy and food. It advocates for creating systems that maximise synergies and minimise trade-offs among fragmented sectors, aiming to optimise the sustainable management of natural resources and improve resource use efficiency (Bazilian et al., 2011). Nexus thinking has the potential to generate integrated solutions for achieving some of the Sustainable Development Goals (EU, 2021).

In simple terms, the WEFE nexus acknowledges the interconnectedness of water, food, energy and ecosystem and its crucial role in promoting integrated and sustainable resource management (Simpson & Jewitt, 2019). This approach has the potential to help humans to manage resources sustainably within nature's intricately woven ecosystem. However, despite its potential, some scholars criticise the WEFE nexus for its perceived lack of consideration for the social dimension, particularly livelihoods (Simpson & Jewitt, 2019), a point we will explore further in our findings.

Nepal, nestled in the central Himalayas, has a rich history and tradition of its people living in harmony with nature. Life in diverse landscapes, from steep mountains to plain flood lands, has presented challenges that spurred people to adapt and innovate. This has led to the development of various indigenous systems that have enriched livelihoods while maintaining intricate harmony with nature, often characterised by holistic approaches. Nepal's indigenous systems and technologies are built upon traditional ecological knowledge, emphasising the prudent use of natural resources and resource governance rooted in community-based decision-making (Thapa, 1994; Sharma et al., 2009).

In the early 20th century, Nepal introduced modern services such as hydroelectric power (water, energy), new agricultural crops and livestock breeds (food). However, such services were not integrated into local knowledge at the community level. By the mid-century, with the advent of democracy, the country witnessed the establishment of numerous sectoral departments covering agriculture, food quality, forest, health, irrigation, livestock, plants, roads and more. Presently, there are at least 28 such departments under 22 ministries at the federal level. The new 2015 constitution significantly empowered local governments like municipalities more than pre-2015. However, existing systemic policy, institution, and practice fragmentations have, in turn, shaped the formation of local governance. Unfortunately, in the pursuit of 'modern' governance structures, traditional ecological knowledge with a long history of socio-ecological well-being shaped by holistic approaches seems to be mostly neglected. Despite the power restructuring, various spheres of government, particularly local governments, have not taken into account the holistic approach to natural resource management. Additionally, the roles of federal, provincial and local governments remain vague, causing further uncertainties.

Ideas and policies originating in one context often diffuse to others, even globally (Marsh & Sharman, 2009). While the nexus framework appears clear in theory, translating nexus thinking into practice, especially considering Nepal's diverse socio-economic, political, and cultural contexts, presents challenges. For instance, water, a basic necessity for all, a shared resource and an integral component of the WEFE nexus, is governed by the federal, provincial and local governments under different and often fragmented policies and institutional arrangements. Based on a literature review, field observation and stakeholder interviews, this case study (Ying, 2003) aims to shed light on the challenges of the WEFE nexus approach by examining the governance of agriculture, forestry and resource management.[1]

[1]There are two case studies focusing on different elements, that are showcased in this volume that are all from Manthali in Nepal: (i) A WEFE Nexus Approach: A Case Study of Forest Fires in Manthali Municipality, Ramechhap, Nepal; and (ii) Nexus Approach in Agroforestry: Policy, Community Practices and Institutional Coordination in Manthali Municipality.

View of Tama Koshi river in Manthali, Nepal. Photo: Author

Manthali Municipality, situated in central Nepal, spans an area of 211.8 km². Despite the Tama Koshi river (see Figure 1) flowing through the municipality area, water scarcity remains a pressing issue for its 45,416 inhabitants, affecting both drinking water and agriculture. Higher levels of electrification enable water pumping from the Tama Koshi river to address scarcity for some people. Additionally, severe droughts, forest fires, landslides, and soil erosion exacerbate the socio-ecological problems, which are all expected to worsen with climate change. Despite not being connected to motorable roads until recently, Manthali is not immune to the global challenge of urbanisation. With limited resources and significant livelihood challenges, there is a growing migration trend to urban centres in pursuit of improved socio-economic opportunities. Located just 130 km from Kathmandu, Manthali presents a unique set of interconnected challenges, making it an ideal subject for a Water-Food-Energy-Forest (WFEF) nexus case study. The municipality's current socio-ecological and resource management strategies provide valuable insights into governance issues through the lens of an integrated approach like the WFEF nexus framework.

3. Findings

Most governance actors in Nepal express genuine appreciation for adopting a WEFE nexus approach, with some demonstrating explicit and implicit knowledge of interconnectedness. However, incorporating this integrated nexus thinking into policies, institutions, and practices proves challenging. Governance in Nepal is divided into federal, provincial and local levels - each with different authority and responsibility for managing common resources, including water, food and energy. Despite the constitutional mandate for a District Coordination Committee (DCC) in all districts, over 40 fragmented government agencies operate with minimal coordination. Instead of coordination and cooperation over shared responsibilities in annual programs, there exists a space of mistrust, responsibility shifting, and problem shifting. Institutions within these tiers responsible for water, food, energy and the ecosystem show only need-based coordination but lack a careful,

long-term, sustainable agenda for synergy. Despite shared goals, a tendency persists to function in 'silos' rather than embracing the integrated approach proposed by the WEFE nexus framework.

Some knowledge about the nexus approach also prevails among practitioners, particularly among the older generation whose livelihoods depend on forestry and agriculture. Social, cultural, traditional, spiritual and power dynamics are interwoven into their understanding and practices of the WEFE nexus. For a resident next to the community forest, the forest has been integral to his lifestyle and livelihood for over eighty years, allowing him to find mutual symbiosis with the forest ecosystem. He observes this once omnipresent integrated approach of knowing and doing to be fleeting, highly exacerbated by outmigration. In addition to the lack of integration of water, energy and food, another farmer in Manthali expressed collective grief about the increasing commodification of food and societal neglect of small-scale farmers despite their indispensable role in feeding the local community. The challenges faced by these individuals highlight the growing disconnect between the water-energy-food-ecosystem, leading to unsustainable resource management, increased hardship, lowered income, and marginalisation.

How can we bridge the awareness-action gap within the nexus? While the idea of rewriting the national constitution and restructuring policies and institutions may seem impractical, fostering acknowledgement among stakeholders of the benefits inherent in the nexus approach could serve as a starting point towards realising nexus thinking and actions. Practitioners and policymakers hold considerable control over policy and institutional dynamics, thus influencing overall governance. Our findings reveal a pervasive mistrust among governance actors and practitioners, highlighting a recurring need for more proactive collaboration. While initiatives centred around WEFE nexus-oriented capacity building, knowledge co-creation and sharing show promise, entrenched patterns of neglect, lack of care, self-serving narratives and questionable work ethics perpetuate silos rather than fostering integrated efforts. Addressing this issue transcends mere awareness of the WEFE nexus; it necessitates embodying, implementing, measuring and monitoring the nexus approach. Moreover, it demands heightened accountability among critical stakeholders, particularly those in positions of power, to the broader general population.

In examining policies, institutions and practices aligned with the WEFE nexus, we observed an absence of links to gender equality and social inclusion (GESI). This gap may arise from either the entrenched patriarchal structure in Nepal or the oversight of the social dimension within the WEFE nexus framework, as often highlighted by other researchers (Simpson & Jewitt, 2019). Employing a dedicated research framework focused on GESI (see IDPG, 2017) could offer a more accurate representation of inclusion in Manthali and elucidate how it could enhance the WEFE nexus thinking and action.

4. Recommendations

4.1 Co-creation

For contextually relevant and socially legitimate change-making, developing a comprehensive understanding of the local context and collaboratively generating transdisciplinary knowledge regarding the relevance and significance of the WEFE nexus is crucial. This involves facilitating workshops to empower nexus thinking, bridging fragmented policies and institutions, nurturing relationships and empowering nexus thinking and action. A starting point would involve co-creating a nexus roadmap to identify pertinent stakeholders, including marginalised communities and

explore synergies for a more integrated approach to local policies, development projects and annual programs.

4.2 Trust Building

Building trust among stakeholders is critical for fostering integrated approaches and identifying synergies. This necessitates time, resources, capabilities, openness and the collaboration of stakeholders with diverse powers, interests, conflicts and influences. The process of bringing pluralistic values together involves inclusion, co-creation and legitimacy. Establishing trust could serve as the foundation for integrating the WEFE nexus or a similar framework to promote sustainable resource governance.

4.3 WEFE Nexus: Fit for Manthali?

Incorporating additional dimensions such as culture, spirituality and power dynamics into the nexus framework in Manthali is essential. Our findings resonate with scholars who have highlighted the omission of the social dimension in the existing WEFE discourse. Homegrown nexus-influenced solutions incorporating existing integrated approaches are crucial to translating nexus ideas into action.

4.4 Homegrown Solutions

WEFE nexus represents just one of several resource governance approaches. The challenge lies in developing a locally tailored approach that fits the context of Manthali. Adopting more comprehensive, non-western, and locally rooted methodologies that incorporate diverse values and draw insights from indigenous governance approaches like *Swaraj, Buenvivir and Ubuntu* (see Kothari et al., 2019) could play a crucial role in collaboratively developing a WEFE nexus-oriented resource governance approach tailored to the specific context of Manthali. This approach must incorporate the social dimension and might involve a contextual and comprehensive assessment combining top-down and bottom-up strategies. Figure 2 contextualises and re-visualizes the nexus linkages, aiming for nuanced solutions that effectively address the unique challenges in Manthali. By utilising existing platforms like the DCC, integrative processes should concentrate on identifying

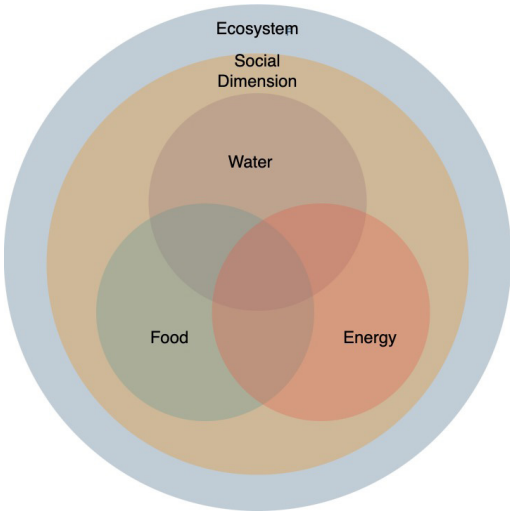

Figure 2. Research emphasises the importance of integrating the Water-Energy-Food (WEF) nexus within the social and ecosystem dimensions in Manthali for homegrown solutions.

synergies among diverse actors with shared responsibilities but diverse and varying knowledge and powers. For instance, local governments, with the authority to create local policies, budgets and programs, can collaborate with federal agencies that are primarily responsible for implementing federal policies and programs. The latter might also have access to more knowledge, technology, funds and other resources.

5. Conclusion

The WEFE nexus, whether explicit or implicit, is present in policies, institutions, and practices in Manthali. While stakeholders increasingly recognise the advantages of an integrated approach to resource management and good governance, they continue to operate in silos, maintaining the status quo. Insights from Manthali underscore the need for a reinforcing loop for homegrown solutions, incorporating the WEFE nexus approach to meet the specific needs of the region. This involves co-creation processes, encompassing both grassroots and top-down approaches and acknowledging the sociocultural dimensions often overlooked by the current WEFE nexus framework.

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Nexus Approach in Agroforestry: Policy, Community Practices and Institutional Coordination in Manthali Municipality

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Introduction

Climate change disrupts water availability and agricultural productivity, jeopardizing food security. In response, agroforestry – a land-use practice integrating trees, crops, and livestock – is gaining traction due to its potential to enhance resilience and sustainability. Agroforestry, deeply rooted in ecological principles, serves as a dynamic approach to natural resource management, by integrating trees within agricultural landscapes, ranching operations and diverse environments (Kitalyi et al., 2013; Jose et al., 2021). This traditional practice intertwines the cultivation of trees and shrubs within and around agricultural fields and is widely recognized for its economic and environmental benefits (Ranjitkar et al., 2016). It epitomizes the intricate connections among water, energy, food and land resources, all facing critical challenges exacerbated by climate change impacts. These challenges are further compounded by socio-economic development and population growth, intensifying the demand for food, energy, water and land resources amidst projected shortages and environmental degradation.

The practice of integrating tree species alongside agricultural crops, pastures and animals holds deep historical roots in Central and South Asia, including Nepal (Ranjitkar et al., 2021) and persists to this day. In Manthali Municipality, located in the Ramechhap district of Central Nepal, agroforestry has been a prevalent practice for over two decades. However, prolonged dry spells have triggered severe water scarcity, escalating climate-induced drought as a significant environmental concern (Bhuju et al., 2013). The resulting water scarcity, affecting both drinking needs and irrigation, has adversely impacted livelihoods, prompting migration and the abandonment of agricultural lands (Chapagain & Gentle, 2015). Despite a decade of discussions, effective solutions have remained elusive. Nevertheless, there is a growing recognition that agroforestry as a traditional mixed farming practice, holds promise as a practical and effective approach to enhancing productivity in climate-sensitive, river-beds, wastelands and water-scarce areas (Ranjitkar et al., 2024).

Agroforestry system involves trade-offs, such as balancing energy needs (fuelwood) with food production (crops), optimizing arable land for forests or extensive cropping, and managing water allocation while considering its impact on the water cycle. It also diversifies food sources by creating multi-layered systems that can provide fruits, nuts, and fodder alongside traditional crops. However, maximizing these advantages requires a holistic approach that considers the interconnectedness of vital resources – water, energy, food, and ecosystems (Al-Saidi & Ribbe, 2017). This is where the Water, Energy, Food, and Ecosystem (WEFE) nexus comes into play.

Water, Energy, Food and Ecosystem (WEFE) Nexus in Agroforestry

The WEFE nexus in agroforestry refers to the interconnected relationships among water, energy, food and ecosystems within the context of integrating trees and shrubs into agricultural landscapes (Li et al., 2021) and, especially concerning water security and regional climate dynamics (Aris and Agung Wahyu, 2023). Importantly, the WEFE approach in agroforestry aligns with the Sustainable Development Goals (SDGs) by promoting cohesive policies for broader landscape management. This expanded agroforestry paradigm coexists with earlier concepts, highlighting the intricate interactions between trees, crops, livestock, and the management, knowledge, values, incentives and intentions of farmers across plot, farm and landscape levels (Van Noordwijk et al., 2018; Van Noordwijk, 2020). The impending impacts of global climate change, particularly alterations in the water cycle leading to unpredictable rainfall and increased extreme events, will significantly affect various Sustainable Development Goals (Van Noordwijk, 2020). This interplay between water (SDG 6) and its connections with food (SDG 2), health (SDG 3), energy (SDG 7), climate change (SDG 13), life on land (SDG 15), and life under water (SDG 14) underlines the intricate web of interdependence among these goals (Ranjitkar et al., 2024).

Furthermore, the role of agroforestry in the WEFE nexus encompasses:

1. **Water Nexus:** Agroforestry mitigates drought impacts by reducing erosion, improving water retention, and recharging groundwater, thereby supporting sustainable water use in agriculture.

2. **Energy Nexus:** Agroforestry systems offer renewable fuelwood sources, reducing reliance on traditional energy and lessening pressure on natural forests, contributing to energy sustainability.

3. **Food Nexus:** Agroforestry diversifies agricultural production, increasing farm productivity and resilience, ensuring a stable and varied food supply.

4. **Ecosystems Nexus:** Agroforestry offers biodiversity habitats, carbon sequestration, soil fertility enhancement, and overall ecosystem resilience (Li et al., 2021; Paudel et al., 2019).

While Aris and Agung Wahyu (2023) and Correa-Porcel et al. (2021) effectively highlight the interconnectedness within the WEFE nexus of agroforestry, a deeper understanding of the specific strategies and techniques employed for practical implementation is needed. By delving deeper into these methods, this study aims to investigate the current application of the WEFE nexus in Manthali Municipality and identify opportunities for strengthening institutional coordination. This will ultimately provide a practical guide for stakeholders, policymakers, and communities seeking to implement the WEFE nexus approach in their agroforestry initiatives, promoting sustainable resource management and enhancing climate resilience.

2. Materials and Methods

2.1. Study Area

The study was conducted in Manthali Municipality in Ramechhap district, an area which is recognized as one of the most drought affected regions in Nepal.

2.2. Methodology

A comprehensive research approach was employed to understand the WEFE nexus in agroforestry within Manthali Municipality. Field observations were conducted to directly examine the interconnected systems, assessing the dynamics between water, energy, food and ecosystems. Stakeholder interviews involved engaging with farmers and government officials from irrigation, forest and agriculture sectors to understand their perspectives and experiences within the WEFE nexus. Additionally, policy related documents and relevant research articles were extensively reviewed to contextualize the findings and establish a theoretical framework for the study. The integration of field observation, stakeholder perspectives and literature reviews provide a holistic understanding of the WEFE nexus in agroforestry.

Findings

3.1 Nexus Approach in Policy Implementation

3.1.1 Nepal's Response to Climate Change

In Nepal's historical context, the formulation of the National Adaptation Programme of Action (NAPA) represents a significant step towards aiding vulnerable populations in mitigating the adverse impacts of climate change. Aligned with NAPA priorities, the Government of Nepal introduced the National Framework on Local Adaptation Plans for Action (LAPA). Endorsed by the Ministry of Environment, LAPA serves as a vital roadmap for implementing NAPA Priority Programs and establishing a comprehensive LAPA Framework.

This framework facilitates the prompt and effective delivery of adaptation services, thereby supporting the practical implementation of NAPA priorities (Peniston, 2013).

3.1.2 Recognition of Agroforestry in Local Adaptation Plans

The LAPA document, drafted by Resources Himalaya in 2013, identifies agroforestry as a highly effective adaptation strategy for communities residing in water-stressed regions such as Manthali. Within the LAPA document, agroforestry is acknowledged as a strategic measure to address challenges posed by water scarcity and provide a sustainable solution to bolster resilience and livelihoods in these vulnerable areas. However, despite various policy-related documents advocating for an integrated approach to resource management, there is a notable absence of exploration of the WEFE nexus approach, particularly concerning water, energy, food and ecosystems.

3.1.3 National Agroforestry Policy Implementation

Nepal has achieved a significant milestone in national agroforestry by becoming the second country globally to adopt a comprehensive National Agroforestry (AF) Policy (GoN, 2019). This policy emphasizes several key aspects, such as prioritizing commercial and collective farming, improving farmers' access to markets, supporting industry-based agroforestry initiatives, providing incentives to encourage agroforestry adoption, promoting agroforestry on fallow lands, and establishing specialized area-based agroforestry models (Khadka et al., 2021). While this policy reflects a commitment to an integrated approach to resource management, there is a need for more explicit considerations of nexus dynamics, particularly regarding the interaction of water, energy, food and ecosystems.

3.1.4 Opportunities for Enhanced Policy Integration

Despite Nepal's commendable steps toward developing comprehensive policy frameworks, there is an evident opportunity for explicitly integrating nexus dynamics into these policies. Addressing the intricate interdependencies of the WEFE nexus within policy frameworks aimed at sustainable development, climate adaptation and natural resource management could significantly augment their effectiveness.

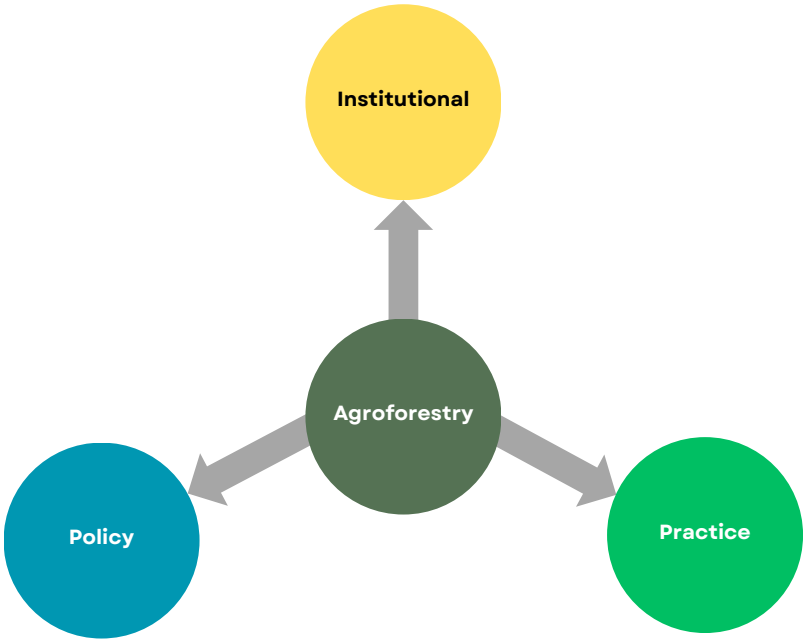

Figure 1. WEFE Nexus Diagram

(The size of the arrow indicates the strength of the nexus)

3.2 Nexus at Institutional Level

The examination of district and municipal offices responsible for irrigation, agriculture and electricity, aimed to assess the adoption of the nexus concept by institutions crucial for promoting agroforestry in drought-affected areas. However, the findings revealed that each institution operated independently without collaboration or coordination. For instance, both the irrigation office and the agricultural knowledge center in Manthali Municipality allocated funds for irrigation facilities, but only a few communities received partial support from both institutions for their field's irrigation, as the support from a single institution was insufficient.

Similarly, discussions with respondents revealed that budget constraints significantly hampered performance and satisfaction at both institutional and community levels. Interestingly, when the concept of the WEFE nexus was introduced, concerned authorities recognized its innovative potential and acknowledged that a nexus approach could amplify impact. Albeit unknowingly, the community had been reaching out to all institutions, leveraging limited resources and support, and actively practicing the nexus approach. Moreover, community institutions led by women and the underprivileged (such as farmer's groups and women's groups) have been prioritized by the local government in terms of incentives and grants for promoting agroforestry. They are effectively mobilizing resources from different sectors and fostering collaboration.

Implicit Nexus Approach to Thriving Agroforestry: A Case Study

The Majhi community, known as the fisherman community, resides along the riverbanks and depends primarily on fishing for their livelihood. Faced with challenges such as declining fish stocks and a reduction in alternative income-generating activities like construction work, many community members have sought new avenues beyond their traditional occupations.

Upon returning to his local community after years of working abroad, Ek Bahadur Majhi was driven by a renewed sense of commitment to improve the wellbeing of his community. Realizing the potential of agroforestry, he rallied individuals who shared his vision, particularly young men and women, to form a committee and farmers' group. Collectively, they tapped the assistance programs provided by the Manthali Municipality, and received essential resources such as seeds, fertilizers, water-lifting assistance as well as financial aid from local NGOs. With this support, they revived their traditional occupation of fish farming.

This collaborative endeavor resulted in the widespread adoption of large-scale agroforestry initiatives within the community, with all members equally benefiting from the outcomes. Going beyond mere material gains, the community wholeheartedly embraced a nexus approach in their initiatives. This comprehensive strategy illustrates the interconnectedness between water, energy, food and ecosystems, thereby enhancing the overall welfare of the community.

3.3 Nexus in Practice

Naboghat, situated along the Sunkoshi River, is home to more than 60 households of the Majhi community. Traditionally reliant on fishing for sustenance, the community has diversified its livelihood activities to include labor, agriculture and various other income-generating activities. Embracing change, they have implemented agroforestry practices across the expansive river floodplain, integrating fruit tree plantations with cash and food crops, and incorporating fish farming. This holistic approach, incorporating trees, shrubs, crops and livestock, yields synergistic benefits, establishing a nexus between water, energy, food and the ecosystem.

In their pursuit of improved livelihoods and resilience against climate change impacts, the community collaborates with government and non-government entities and undertakes initiatives such as constructing irrigation canals and harnessing electricity. Noteworthy is the active involvement of women in agroforestry endeavors to secure their livelihoods, particularly as their male counterparts seek employment abroad.

However, field observations have revealed certain challenges in the sustainability and maintenance of these initiatives, where locals inadvertently adopt a nexus approach driven by the imperative to improve livelihoods. Ek Bahadur Majhi, a local resident and president of a community-based agri-farm, recounted his experience securing funds and

grants from government and non-government entities to construct an irrigation canal for extensive land irrigation. Unfortunately, a breach in the canal's embarkment after a flood led to a 50% decline in productivity this year, leaving them uncertain about where or how to seek assistance. Furthermore, insufficient funds for fishpond repairs have compounded their challenges.

In the context of the nexus approach, the transition from biomass energy to biogas is noteworthy. This shift offers several benefits: it reduces air pollution and deforestation by providing a cleaner and more efficient way to utilize biomass compared to traditional fuelwood burning. Additionally, by freeing women from time-consuming fuelwood collection, it allows them to dedicate more time to wage-based agricultural work, potentially increasing household income. However, a potential challenge arises – as communities adopt biogas and rely less on forest resources for energy, their traditional forest management practices might weaken. This decline in community involvement could negatively impact the ecological balance of local ecosystems. Integrating agroforestry practices within the WEFE nexus framework with integrated crop-livestock-multipurpose trees can contribute to a balanced approach. Additionally, these systems can enhance biodiversity and soil health, contributing to the overall ecological balance within the WEFE approach and achieving SDG goals (Ranjitkar et al., 2021, 2024).

Conclusion

The case study conducted in Naboghat, along the Sunkoshi River, vividly demonstrates how the nexus approach seamlessly integrates into agroforestry, showcasing the Majhi community's adept adaptation to evolving livelihoods and the impacts of climate change. Their transition from traditional fishing to a diversified agroforestry system along the floodplain, incorporating fruit tree plantations, cash and food crops, and fish farming, serves as a tangible testament to the merits of adopting a holistic nexus approach that interconnects water, energy, food and ecosystems. This comprehensive strategy not only bolsters resilience but also nurtures sustainable practices, addressing a multitude of interconnected facets pivotal to the community's well-being.

Within the domains of irrigation, agriculture and electricity management at the municipal offices, a noticeable lack of coordination is evident, underscoring the urgent need for a more unified institutional approach. While authorities recognize the innovative potential inherent in the nexus concept, a clear opportunity exists for these institutions to synergistically collaborate, thereby amplifying the impact of agroforestry initiatives in drought-affected regions.

Remarkably, despite lacking explicit knowledge of the nexus approach, the community inadvertently epitomizes its principles through practical application and proactive engagement with relevant institutions. This underscores the immense potential for heightened collaboration and concerted efforts among institutional stakeholders. Leveraging this potential holds the key to optimizing the effectiveness of agroforestry

practices and effectively addressing the multifaceted challenges present in drought-affected areas.

In essence, the case study highlights the need for cohesive institutional coordination, leveraging the community's implicit nexus-driven actions to harness the full potential of agroforestry initiatives. By fostering collaborative partnerships and knowledge sharing among stakeholders, a more integrated and impactful approach can be realized, contributing significantly to sustainable resource management and resilience-building in vulnerable regions.

3. Recommendations

Enhancing the integrated management of food-energy-water-ecosystem resources in Manthali requires a multifaceted approach. The following initiatives serve as fundamental steps:

1. Institutional Coordination: Promote synergy among municipal offices responsible for irrigation, agriculture and electricity by initiating collaborative strategies and operations within the municipality. To establish a coordinated approach among municipal offices, leadership from elected representatives and department heads overseeing, agriculture, forest, irrigation and electricity/energy is crucial. They should collaborate closely with provincial ministries or regional authorities, community stakeholders, technical experts and NGOs. This collective effort ensures alignment of policies, resources and community engagement towards maximizing the impact of agroforestry initiatives, particularly in drought-affected areas. By fostering open communication and collaboration, the platform can identify opportunities for synergy, streamline processes, and overcome potential obstacles.

2. Awareness and Training: Organize targeted awareness programs and training sessions for institutional authorities to highlight the benefits and potential of the nexus approach in agroforestry. Emphasize the amplified impact and improved outcomes achievable through concerted efforts and coordination among departments.

3. Community Engagement: Acknowledge and capitalize on unintentional nexus practices observed within communities, exemplified by those in Naboghat. Foster synergy among municipal offices responsible for key sectors by promoting collaboration. Facilitate dialogues between community members and relevant institutions to formalize and strengthen these practices, cultivating a mutually beneficial relationship.

4. Policy Integration: Advocate for the explicit inclusion of the WEFE nexus in relevant policy documents to enhance the LAPA's recognition of agroforestry as a strategic measure. By integrating the nexus concept, policymakers can establish a comprehensive framework for sustainable development, climate adaptation, and effective natural resource management.

5. Research and Innovation: Invest in research and innovation endeavors aimed at comprehensively understanding and documenting the nexus dynamics in agroforestry practices. This acquired knowledge can substantially influence policy decisions, refine institutional practices, and empower communities to adapt proactively to evolving environmental conditions.

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Examining Dhorpatan Hunting Reserve Through the WEFE and GESI Lens

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Synopsis

The Dhorpatan Hunting Reserve (referred to as DHR or the Reserve), which is situated in the remote regions of Baglung, Myagdi and East Rukum districts, serves as the focal point for this analysis. This case study incorporates the Water, Energy, Food, and Ecosystems (WEFE) nexus as well as the Gender Equality and Social Inclusion (GESI) as a pivotal cross-cutting theme to highlight the nexus's potential contributions toward achieving Sustainable Development Goals (SDGs).

The reserve is endowed with abundant natural springs that support diverse flora and fauna, along with vital forest resources crucial for local communities. It provides opportunities for community-led conservation, tourism, and the preservation of cultural traditions. However, it is under the threat of over-exploitation and unregulated infrastructure development, such as roads and hospitals, which jeopardize the unique landscape of this remote area.

Despite its immense potential, the Reserve lacks interlinkages with other sectors (water, energy and food) and associated institutions. In addition, it falls short in implementing inclusive practices for women and socially marginalized communities. The management tends to adopt short- sighted solutions for forest ecosystem management and overlooks the negative implications or trade-offs in other thematic areas, including energy, water and agriculture. Thus, there is an urgent need for a comprehensive and sustainable approach to guarantee the long-term vitality of both the ecosystem and local communities in this ecologically and culturally significant region.

Data for this case study was acquired from the Reserve's Management Plan, from secondary sources, face to face interviews with 30 local residents and authorities, and a comprehensive literature review of the selected WEFE nexus articles mentioned in the reference list.

Background

The DHR in western Nepal, was initially established in 1983 as a hunting reserve. It has since shifted its focus towards conservation and sustainable tourism. Nestled amidst the scenic Dhaulagiri and Annapurna ranges, spanning across Baglung, Myagdi, and East Rukum districts. This reserve encompasses diverse ecosystems ranging from lush evergreen forests to snow-clad meadows and towering mountains (DHR, 2022). With a rich biodiversity that includes 32 mammal and 137 bird species, including the elusive snow leopard, the DHR serves as a cultural hub for communities such as the Nauthars, Kham Magars, Chhantyals and Gurungs, whose traditional practices, notably the transhumance-based agro-pastoralism, contribute to the area's distinctiveness.

This article examines the role of a Hunting Reserve in preserving a condensed terrestrial forest ecosystem, thus maintaining the crucial ecosystem services, while also providing water, energy and food security for local livelihoods. Moreover, it directly contributes to at least six SDGs. These include:

	End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
	Achieve gender equality and empower women and girls.
	Ensure availability and sustainable management of water and sanitation.
	Ensure access to affordable, reliable, sustainable and modern energy.
	Take urgent action to combat climate change and its impacts.
	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

Water Security

The Reserve relies heavily on high mountain sources, with key rivers such as Uttar Ganga, Ghustung, Dogadi Purbang, Pelma and Seng that play a crucial role. Converging in the southeastern valley, Gur Gad and its tributaries join the Uttar Ganga, flowing south to Gurjaghat, then west to Dhorpatan. Prominent rivers like Gustung and Dogadi, originating from glaciers, are vital components of the region. The valley, enriched with tributaries, serves as a habitat for Blue Sheep and Himalayan Tahr. Preserving high-mountain wetlands is crucial globally, as they act as essential water towers and provide habitats for migratory birds.

Snow-fed rivers like Seng, Ghustung, and Dogadi Khola sustain aquatic habitats, although conservation faces challenges such as pollution, over-grazing, and impacts from climate change. DHR is likely to have abundant natural springs, serving as a consistent and reliable freshwater source for the ecosystem.

Well-maintained water sources play a pivotal role in preserving the diverse flora and fauna within the hunting reserve. Additionally, these water sources supply drinking water to approximately 24,472 people, residing in 5,193 households within the proposed buffer zone inside and outside the DHR. Within the reserve itself, 53 settlements with a total of 2,945 households benefit from these water sources (DHR, 2019). The water sources in the DHR area carry significant cultural importance for local communities, contributing to the rich cultural heritage of the region. Notably, Dhor Barahi, a famous pilgrimage site in the area, plays a role in preventing water pollution in sources like the Uttarganga River

The flowing water in the region presents opportunities for sustainable hydropower generation, contributing to local energy needs. The proposed Uttarganga Hydropower Project, a flagship project of the Gandaki province, holds significant potential for water-based entertainment and adventure, including rafting, boating and canyoning around the constructed dams. This may encourage nature-based tourism in the DHR.

Despite these positive aspects, the Reserve faces risks of water contamination due to agricultural runoff, human activities, direct sewage connection to rivers, and potential pollution from tourism-related activities. Changes in precipitation patterns and temperatures induced by climate change could affect the volume and reliability of water sources, potentially leading to shortages. Climate change has transformed the white capped mountains into black and brown rocky areas and there is a notable decrease in water discharge into the rivers. Wetlands, particularly in the Dhor area, are being disturbed. Inadequate infrastructure for water management and the conservation of water bodies like rivers, ponds, springs and glacier lakes may result in inefficiencies and a lack of resilience to climate-induced challenges. Road construction using bulldozers has disturbed the natural course of water sources, leading to increased runoff, landslides and floods in the area, further exacerbating the drying out of water sources. If not managed properly, the influx of tourists may lead to the over-extraction of water resources, impacting the local ecosystem. Increased tourism activities could result in the over exploitation of resources

including water and forest resources, particularly for firewood. Alterations in land use patterns, particularly deforestation, can have adverse effects on water sources, negatively influencing water quality and availability. This, in turn, impacts water availability and the continuity of water discharge in the rivers.

The region is also susceptible to natural disasters, such as landslides and floods, which pose a threat to the integrity of water sources. Natural disasters can have negative consequences for water availability, cleanness and water quality. Insufficient regulations for water management may lead to uncontrolled use and potential degradation of water quality. The proposed Uttarganga Hydropower Project, a dam hydropower initiative, may impact the continuity of water flow in the Bheri River, as the project aims to divert water to Baglung district. Furthermore, it could have a negative impact on the aquatic life of the Bheri River.

Despite these challenges, the Reserve presents enormous opportunities for engaging local communities in water conservation initiatives to enhance the protection of water sources and promote sustainable practices. Initiatives for sustainable tourism can be developed around water sources, providing economic incentives for conservation efforts. The Homestay Association is actively involved in the DHR, promoting sustainable tourism in the area. Additionally, conducting research on local water sources can provide insights into the impacts of climate change, aiding in the development of adaptive strategies. The Department of National Parks and Wildlife Conservation, the DHR Authority and students of universities and research institutions are actively involved in conducting research in the region as well.

Energy Security

Currently, firewood serves as a primary source of energy for local communities, but its availability is gradually diminishing due to increasing demand within and around the DRH. The Uttarganga Hydropower Project in Dhorpatan, envisioned as one of Gandaki Province's flagship projects, holds the potential to generate 828 megawatts of electricity. Moreover, the region could harbor untapped hydropower potential owing to its abundant rivers and water bodies, presenting an opportunity for sustainable and clean energy.

Dhorpatan's high-altitude location also offers possibilities for solar and wind energy projects, contributing to a diversified and resilient energy mix. Involving local communities in these energy projects not only enhances social acceptance but also creates job opportunities, ensuring the benefits reach the community. Implementing sustainable energy solutions can contribute to biodiversity conservation by reducing dependence on traditional, environmentally harmful energy sources.

Integration of hydropower, solar and wind energy coupled with a reduction in firewood usage, can synergize efforts and ensure energy security in the area. While the rich biodiversity has traditionally provided firewood to local communities, excessive extraction from the forest and DHR may lead to trade-offs, impacting the environment and social aspects, such as increased time for firewood collection.

Currently, 96.8% of households in Nisikhola Rural Municipality, both within and outside the DHR, rely on firewood as their primary cooking fuel (Nisikhola RM Profile, 2019). A similar situation in neighboring municipalities has contributed to the widespread use of firewood for cooking energy. This common practice amplifies the trade-off within the WEFE nexus, resulting in an overall negative impact on the net WEFE nexus up to the present.

Establishing community-based microgrids powered by renewable energy sources (solar, wind, hydro) can also provide a reliable energy supply to remote areas. Integrating renewable energy solutions into tourism infrastructure enhances the sustainability of the tourism sector and reduces its environmental impact. Moreover, the proposed Hydropower Project opens opportunities for nature based eco-tourism, such as boating, canyoning, rafting and fishing, potentially increasing revenue generation for the local government and creating employment opportunities for the local people.

Building local capacity for installing and maintaining renewable energy systems has the potential to create job opportunities and empower the local workforce. However, the absence of well-established energy infrastructure might impede the utilization of available renewable energy sources, leading to dependence on traditional energy forms. Challenges include the absence of an electric transmission line, connection to the national electricity grid and other infrastructures such as roads, drinking water facilities, marketing and communication. Limited financial resources may also present challenges for implementing large-scale renewable energy projects, necessitating strategic partnerships or funding initiatives.

Changing weather patterns and extreme events can also affect the reliability and efficiency of renewable energy sources, potentially impacting the energy supply. The remote location of Dhorpatan makes energy infrastructure vulnerable to natural disasters such as landslides, affecting the continuity of energy supply. The lack of clear regulations and planning for energy projects may lead to uncontrolled development, impacting the environment and local ecosystems. The lack of awareness and education about the benefits of renewable energy may hinder community support and engagement in sustainable energy initiatives.

Most of the water sources in the DHR area drain into the Bheri River, a major component of the Karnali River system. People living in proximity to the river depend on it for drinking water, irrigation and fishing. The proposed Uttarganga Hydropower Project may potentially impact the livelihoods of the East Rukum's people and disturb the Bheri diversion.

Food Security

Dhorpatan boasts rich agricultural diversity, cultivating a variety of crops such as potatoes, barley, maize, wheat and buckwheat, that forms the foundation for local food production. The region's forest-based edible fruits include walnuts, chestnuts, bayberries, various edible mushrooms and high value medicinal plants, that supplement the nutritional needs of locals. The surplus is sold in local markets and nearby cities such as Burtibang, Galkot,

Baglung, Kusma and Pokhara, contributing partially to the economy. However, farmers face challenges in storing surplus agricultural products, forcing them to sell their products at lower prices than the market rates.

For instance, organic potatoes command a market rate of NRP 120/kg at Burtibang, while farmers in Dhorpatan have to settle for NPR 80/kg, primarily due to seasonal migration to lowlands, which allows middleman to reap higher profits. This scenario poses a threat to food security in the Dhorpatan region. Currently, the cultivation of apples, peaches and walnuts is gaining momentum, and provides good market value. The region embraces traditional and organic farming practices and fosters the production of unique and culturally significant local food varieties. However, inadequate transportation and storage facilities, coupled with seasonal migration from high altitudes to low altitudes during the winter season, result in locals struggling to secure reasonable prices for their agricultural and livestock products.

The prevalence of the transhumance system in the DHR presents an opportunity for unique pastoralism in the mid-hills of Nepal and for promotion of tourism. The region's authentic local food offerings can promote culinary tourism and attract visitors interested in experiencing traditional and indigenous cuisine.

The DHR is globally renowned as a hunting reserve, where domestic and international tourists with hunting licenses from the authorities, are allowed to hunt the Himalayan tahr and wild boars. Moreover, the area showcases natural purity and cultural distinctness, encompassing the Nauthar, Kham Magar, Gurung and Chhantyal cultures, amidst a backdrop of beautiful landscapes and a rich biodiversity. Therefore, the region holds immense potential for nature-based tourism and research sites. The practice of transhumance-based agro-pastoralism supports the sustainable use of grazing lands and traditional livestock farming, contributing to the availability of local meat and dairy products.

Implementing market promotion strategies can open avenues for local farmers, linking them to wider markets and enhancing the economic value of their produce. Leveraging the uniqueness of local food varieties and traditional farming practices can attract tourists interested in culinary and agro-tourism experiences. Adding value to local products through processing and packaging can enhance their market appeal and create opportunities for income generation.

Numerous challenges and threats present obstacles to ensuring food security in the region. The absence of effective marketing channels and essential infrastructure, for example, may restrict local farmers' access to broader markets, thereby limiting economic opportunities. Agricultural productivity remains susceptible to weather variations and the impacts of climate change, potentially affecting the quantity and quality of food produced. Altered weather patterns and unpredictable climate conditions pose threats to agricultural productivity, influencing crop yields and overall food security. The increasing adoption of commercial farming practices may potentially compete with traditional farming methods, jeopardizing the authenticity and uniqueness of local food. Inadequate infrastructure,

including transportation and storage facilities, heightens the risk of post-harvest losses and constrains the potential for market expansion.

Shifting dietary preferences towards processed foods may further impact the demand for traditional and locally grown food products. Establishing a cold store and engaging in food processing in Dhorpatan valley can raise the potential to achieve food security. These initiatives will not only enhance synergy with food security but also mitigate trade-offs linked to environmental damages and societal costs associated with food supply.

Ecosystem and its Services

The DHR serves as a sanctuary for diverse flora and fauna, hosting more than 32 mammal and 137 bird species that contribute to a resilient and vibrant ecosystem. Its unique mid and high-mountain ecosystem offers a varied habitat, nurturing a diverse range of plant and animal species. Indigenous cultural practices, such as transhumance-based agro-pastoralism, positively contribute to maintaining the ecosystem by promoting sustainable land use. Additionally, the area is culturally rich with traditions of the Nauthar, Kham Magar, Gurung and Chhantyal communities. The Reserve's outstanding beauty and biodiversity create opportunities for sustainable tourism, actively contributing to conservation efforts and supporting local livelihoods. The Puspalal Mid-Hill Highway connects the DHR with Pokhara, a prominent tourist destination and Surkhet, one of the commercial hubs of Nepal.

Sustainable tourism initiatives provide an opportunity to raise awareness about ecosystem conservation, generate revenue for local communities and fund conservation projects. The declaration of a buffer zone can further enhance protection of the ecosystem by involving local communities in conservation efforts and promoting sustainable land use practices. Allocating 30-50% of the DHR revenue for the conservation of biodiversity, community development and livelihood improvement can significantly contribute to these initiatives. Engaging local communities in conservation projects and providing economic incentives for sustainable practices can further enhance ecosystem protection.

While designated as a protected terrestrial ecosystem for hunting, various issues have been identified within the DHR. Threats such as over-exploitation of forest resources, poaching and an increasing livestock population have contributed to habitat degradation. The growing human and livestock population, coupled with heavy dependance on the Reserve for natural resources by local communities, negatively impacts the DHR's ecosystem. Haphazard infrastructure development, including roads and other facilities, poses a risk to the natural landscape and may contribute to habitat fragmentation. Despite its richness in biodiversity and reputation for trophy hunting of blue sheep and Himalayan tahr, there is inadequate knowledge and information on the impacts of trophy hunting on the population ecology of game animals. Unplanned infrastructure development is causing biodiversity loss and disturbances to the ecosystem in the DHR.

The Reserve authority's lack of adequate human resources, collaboration and partnership efforts has led to irregular monitoring and documentation of the biodiversity and ecology

of the DHR. The ecosystem is vulnerable to climate change, characterized by irregular rainfall, snowfall and prolonged droughts, which can have an impact on the health of plant and animal species. Poaching poses a significant threat to the diverse wildlife in the Reserve, resulting in population declines and disrupting the natural balance within the ecosystem. The absence of specific pro-people legislation for the Reserve may result in insufficient protection and management measures for the ecosystem. Additionally, there is a potential for ambiguity between laws related to protected areas and the prevailing laws of the local governments.

On the one hand, there is a lack of participation from local communities in decision-making processes related to the Reserve. On the other hand, there is an increasing presence of wildlife in the Reserve, including wild boar, leopards and monkeys, causing damage to crop and posing a threat to domestic animals. This has resulted in conflicts between the local people and the DHR authority, creating a tradeoff with the security of domestic animals. Moreover, local communities oppose the declaration of a buffer zone due to escalating conflicts with the Reserve administration. However, if the DHR is declared a buffer zone, the local community will receive 30-50% of the revenue for infrastructure development, livelihood support and biodiversity conservation.

Gender Equality and Social Inclusion (GESI)

Despite the prioritization of GESI strategies in the DHR management plan, with a focus on inclusive stakeholder engagement and income generation for marginalized communities through eco-tourism and community-based enterprises, women and marginalized individuals face challenges in accessing livelihood benefits. This is primarily attributed to the underrepresentation of women in leadership roles and a lack of sensitivity toward the need for an intersectionality perspective for social inclusion, creating barriers to resource accessibility. Additionally, seasonal migration poses challenges to children's education, health and livelihood security.

The majority of people residing in and around the DHR belong to Janajati and the so-called Dalit communities, who are economically disadvantaged compared to other castes. Male migration to nearby cities and abroad, for employment and transhumance pastoralism agriculture practices, increases the demand for more human resources. This has significantly impacted children's education, especially for girls, leading to increased school and university dropouts, and contributing to child marriage.

The DHR management plan, while outlining economic activities, has overlooked critical issues such as child marriage and capacity building initiatives for youth, particularly focusing on education and employment opportunities for girls and women. Addressing these social issues is crucial for the overall well-being and sustainable development of the communities in and around DHR.

Feedback from respondents emphasizes the need for sustainable solutions that not only preserve the environment but also enrich water, energy, farm and forest-based livelihoods. Local voices particularly underscore the significance of recognizing the specific challenges

faced by women, aligning with the GESI and WEFE integration. Unfortunately, locals exhibit limited awareness of the GESI approach and its implementation. The Reserve and local governments have included GESI provisions in their legislation and project design and implementation, but these have not materialized as expected.

On the one hand, women, disabled individuals and marginalized communities are less aware of GESI provisions, and on the other hand, the Reserve and local governments are less responsive to GESI. This has increased trade-offs due to the reduced involvement of women, disabled individuals and marginalized people in the DHR.

To strengthen the WEFE approach in the DHR, recommendations include implementing targeted interventions for women, conducting a thorough diagnosis of social issues from the perspective of intersectionality, addressing cultural barriers and aligning educational and training initiatives with sustainable and interconnected resource management within the broader framework of the WEFE nexus.

GESI Responsive Nexus Solution for DHR

The WEFE nexus approach can significantly contribute to the governance of the DHR by incorporating GESI considerations. Some solutions with the nexus framework include:

- assessing water resources in the DHR area to ensure sustainable practices for agriculture, energy and human consumption;
- analyzing the energy demands and sources in Dhorpatan, with a focus on renewable and clean energy for sustainable development;
- examining agricultural practices and food security to promote sustainable and climate-resilient approaches;
- evaluating the roles of men and women in Dhorpatan, to ensure that development interventions consider and address gender disparities;
- assessing the inclusion of marginalized groups, such as ethnic minorities or indigenous communities, in the development processes;
- examining access to education and healthcare with a special focus on the needs and challenges faced by different genders and social groups.
- developing integrated plans that consider the interlinkages between water, energy, food, and environmental aspects to ensure holistic and sustainable development;
- involving the local community, ensuring representation from all genders and social groups, in decision-making processes related to resource management and development initiatives;
- implementing programs to enhance the capacity of the local community, particularly focusing on women and marginalized groups, in areas such as agriculture, eco-tourism, renewable energy,

and water management;

» establishing monitoring mechanisms to track the impact of development activities on both the WEFE and GESI dimensions, allowing for adaptive management based on feedback;

» advocating for policies that explicitly incorporate WEFE and GESI considerations, ensuring alignment with national and international frameworks for sustainable development; and

» given the uniqueness of the ecosystem, establishing the Reserve as a live museum and research hub for national and international academia, researchers, nature lovers and climate change experts.

Conclusion

The DHR Management Plan has primarily focused on enhancing the capacity and infrastructure of the Reserve and its staff, with a predominant emphasis on hunting management and biodiversity conservation. However, there is a notable gap in the involvement of local communities in the planning and implementation processes. While provisions have been made for water conservation, including the protection of wetland, rivers, springs, lakes and ponds, uncertainties surround projects such as the proposed Uttarganga Hydropower Project. The interconnected nature of eco-tourism and biodiversity conservation is recognized, yet challenges persist in ensuring food security and water conservation, especially regarding guaranteed safe drinking water for the local residents.

Overall, the plan has made strides in applying the WEFE and GESI approaches to some extent. The timely declaration of a buffer zone for the DHR is crucial, fostering trust between the Reserve authority, local governments and the communities living in and around the area. This initiative is expected to increase local engagement, reduce wildlife killings and mitigate deliberative forest fires in the Dhorpatan region.

The integration of the WEFE nexus and GESI into the DHR Management Plan (2019) has the potential to enhance synergy by ensuring biodiversity conservation, promoting ecotourism, improving institutional capabilities of the Reserve authority, and providing compensation for crop depredation and livestock loss caused by wild animals in the Reserve and its buffer zone. The true impacts of this synergy are expected to outweigh trade-offs after the full implementation of the Management Plan.

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An Assessment of the WEFE Nexus in *Patale* Community Forest, Lalitpur, Nepal

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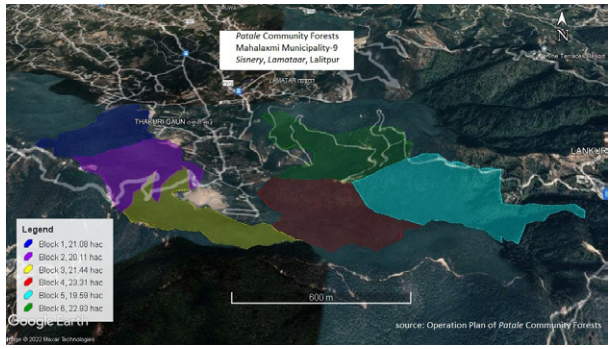
Study Context



Patale Community Forest (CF), handed over on 3 June 1993, is situated in *Lamataar*, Mahalaxmi Municipality, Ward No 9, Lalitpur, Bagmati Province. It is approximately 10 km southeast from Lagankhel bus park in Lalitpur. The distance from Dhungeni local bus park in Sisnery to *Patale* CF can be covered by foot in approximately 10-15 minutes. According to the *Patale* CF Operational Plan (2022)[2], it spans an area of 128.46 hectares of National forests, with elevations ranging from 1,455m to 1,978m mean sea level and slope gradient of 5 to 45 degrees. *Patale* CF shares its' borders with *Mathillo Patale* CF and *Kafle* CF in the east, *Padali* CF and *Raksi Parne Kholso (Rasilo Dol)* in the west, *Sisneri* settlement in the north, and *Patlechhap* CF and Kot Danda, *Bishankhu Narayan* settlements in the south. *Patale* CF comprises of 162 households as its members and has a thirteen-member executive committee, including six women committee members. The ethnic composition of this CF is Brahmin-Chhetri, Adivasi-Janajati and Dalits. Located in the foothills of Kathmandu valley, *Patale* CF exhibits a mixed composition of rural and urban socio-economic and cultural practices. With its scenic landscape and proximity to Kathmandu, the capital of Nepal, *Patale* CF holds significant potential for eco-tourism[3].

The *Patale* CF is situated in a mid-hill area of Nepal, facing towards the northern aspect. It comprises a mixed composition of forests with both broadleaf and coniferous tree species (Photo 1). Dominant among the broadleaf species are Chilauni (*Schima wallachi*) and Katus

[2] *Patale* Community Forestry Operational Plan (2079 BS), fifth revision (Fiscal Year 2078/79 to Fiscal Year 2082/83). Code No.- LAL/SI/06/01 (Draft Version)

[3] Nepal, S. (2007). Good Governance in Natural Resource Management (A Case Study of Patle Community Forest). MA Thesis, Kirtipur, Nepal: Tribhuvan University.

(*Castonapsis indica*). The CF area underwent regeneration from natural forests whereas *Salla* (*Pinus roxburghii*), a coniferous tree species, was planted as part of the Nepal-Australian Forestry Project. Other associated tree species include Uttis (*Alnus nepalensis*), Gobre *Salla* (*Pinus wallichiana*), Lapsi (*Choerospondias axillaris*), Mauwa (*Madhuca longifolia*, among others. The forest quality is moderate, with good natural regeneration at 6,458 seedlings per hectare. The volume of trees and poles measures 62.05 cubic meters per hectares and 91.78 cubic meter per hectare, respectively, with a growing stock is 153.82 cubic meter[4] per hectare. The CF has been divided into 6 blocks, each with an area of approximately 21 hectares, based on forest types, condition, natural boundaries (such as rivers, streams and roads), topography and area, facilitating effective forest management practices[5].

Mix forests: Pine with broad leave tree species. Photo: Author

The fifth revision of the operational plan of *Patale* CF is awaiting approval from the Division Forests Office (DFO), Lalitpur. The draft version of this operational plan has already been prepared by the Mahalaxmi sub-division forest office, Lalitpur. In the fiscal year 2022/23, *Patale* CF received advance payment from DFO, Lalitpur for the construction of an office building, but final settlement is still pending. In light of these developments, the approval process for the Operational Plan of *Patale* CF has been put on hold by the DFO, Lalitpur. However, the Chairperson of the CF has recently submitted supporting documents for the final settlement of the advance payment to DFO, Lalitpur.

Objective and Methodology

The objective of this case study was to assess the WEFE nexus in *Patale* CF. The study involved a half-day field visit to the CF and discussions with key stakeholders, including committee members and forest officials (photo 2). Audio recordings were conducted for digital note taking purposes with prior consent from the respondents.

[4] 1 cubic meter equals to 35.2 cubic feet
[5] *Patale* Community Forestry Operational Plan (2079 BS), fifth revision (Fiscal Year 2078/79 to Fiscal Year 2082/83). Code No.- LAL/SI/06/01 (Draft Version)

WEFE Nexus in CF

The WEFE Nexus highlights the interdependent nature of water, energy, food and ecosystems, emphasizing the need for holistic management. Community forests are instrumental in maintaining this equilibrium.

Water

In his MA thesis, Nepal (2007) observed that the *Patale* national forest area was previously barren and bushy, ravaged by landslides, soil erosion, dried-up spring sources and wildlife migration resulting from the poor quality of their natural habitat. However, after being handed over to the community and converted into the *Patale* CF, there was a gradual improvement in the forest area and its cover, leading to a decrease in landslide occurrences. The *Patale* CFUG (Community Forests User group) prioritized the planting of *Salla* (*Pinus roxburghii*) tree seedlings in the barren land and focused on protecting the forests. Consequently, there was an observed enrichment of greenery. Additionally, the restoration of dried spring source occurred, benefiting approximately 200 households with access to drinking water from the CF.

However, one committee member *Patale* CF, has observed a gradual decrease in the quantity of water from spring sources despite the forest being maintained or improved. Having been involved with the CF since its establishment in various capacities, he suspects that *Salla* (Pine) trees could be one of the reasons for this decline. The sparse ground vegetation beneath the *Salla* trees, caused by the acidic nature of their needles, accelerates surface runoff during the rainy season and reduces the infiltration of rainwater into the ground. Unlike broad leaves, the needles of *Salla* lack the ability to retain rainwater, which increases surface runoff. This contrast in water retention capabilities between needles and broad leaves is akin to comparing a zinc roof and straw roof. The needles of *Salla* trees hinder the recharge of ground water.

Another factor could be the earthquake that occurred in 2015, which altered the underground natural drainage systems and their respective aquifers. As a result, the sources of water for natural spring may have been displaced.

Energy

According to the Operational Plan (OP), *Patale* CF provides firewood and leaf litter, both renewable energy sources, free of cost. Over 70 percent of member households in the CF rely on LPG (Liquefied Petroleum Gas), a non-renewable energy source for cooking and heating. As per the OP there is an annual demand for 7,776 *Bhaari*6 (a local measuring unit) of firewood, while their supply capacity stands at 14,783 *Bhaari*, nearly double the demand.

About 350 families from the Taraai region migrated to the *Lamataar* area in search of better

livelihood options and employment. Most of these migrant households, who either rent rooms or lease land for cultivating vegetables and crops, live in temporary zinc shelters and use firewood for cooking and heating. This reduces the demand for LPG in the local market. Additionally, these households receive leaf litter for producing bio-fertilizer by mixing it with cow dung and urine, which also reduces the demand for chemical fertilizer and its usage in agricultural land. In this context, one committee member claimed that reducing the demands for both LPG and chemical fertilizer, imported from India, would save foreign currency at the national level and reduces trade deficit in the local market. Moreover, the usage of bio-fertilizer in agricultural land helps to maintain and enrich organic matter in the soil. The excessive usage of chemical fertilizer leads to the deterioration of soil organic properties, which could be mitigated by the usage of bio-fertilizer.

There is an opportunity to produce bio-fertilizer using leaf litter from *Patale* and other adjoining CFs as the main sources of raw material. There is a growing demand for bio-fertilizer in nearby urban areas for rooftop and kitchen gardens to produce organic food at household levels. Urban dwellers now prefer organic food for its health benefits. Establishing a bio-fertilizer plant in *Lamataar* area, connected with CFs, would give momentum to the local economy, and generate employment. To accomplish this, the local government should take the lead in collaboration with interested CFs, as local government entities are closest to federal structures in Nepal. The Local Government Operation Act of 2017 empowers local authorities to undertake initiatives in economic development, social welfare and environmental protection7.

Converting leaf litter into bio-fertilizer would be akin to 'cooking two dishes in one pot.' Dry leaf litter in forests is one of the main reasons for forest fire during the dry season, which damages the health of forests ecosystems. Carbon dioxide released from forest fires contributes to air pollution and global warming. In contrast, bio-fertilizer from forest leaf litter contributes to the local economy while reducing the occurrences of forests fire and the release of carbon dioxide into the atmosphere. In essence, it helps enrich organic matters in the soil and maintain the health of forests ecosystem.

Food

As discussed in the 'Energy' section, *Patale* CF has the potential to produce bio-fertilizer from leaf litter. Utilizing bio-fertilizer in the production of organic foods promotes public health, and encourages individuals to minimize their carbon footprints. This also plays a role in reducing carbon emissions per capita at the local level.

Wild and non-cultivated plants found in the forests can provide food and energy for poor and marginalized people living nearby. They can also be sold in the local markets to supplement income. In *Patale* CF, leafy vegetables such as *Nigro* (wild edible fern - *Diplazium esculentum*) and Sisnu (stinging nettle - *Urtica dioica*), along with root crops such as *Ban Tarul* (*Dioscorea spp*), are plentiful. These plants serve as seasonal supplementary sources of organic and nutritious foods. *Ban Tarul*, in particular, holds religious and cultural significance and experiences high demand during *Maghe Sankranti*, a Nepalese festival observed on the first day of the month of Magh in the Bikram Sambat calendar. It is

available in markets before and after *Maghe Sankranti* and is consumed at the household level for its religious and cultural importance as well as its nutritional value. During these periods, the vegetable markets are dominated by Tarul.

The contribution of wild and non-cultivated plants in reducing food insecurity cannot be underestimated.

Ecosystem

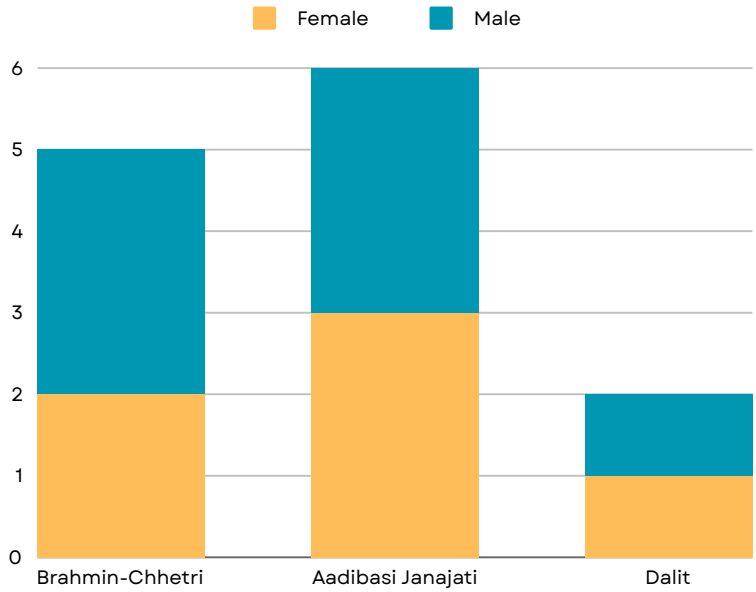
Presently, *Patale* CF provides firewood and leaf litter to the local community. However, following the forest management guidelines specified in the revised Operational Plan would enhance this beneficial practice and safeguard the long-term health of the forest ecosystem.

GESI (The Gender Equality and Social Inclusion)

Mr. Hira Bahadur Poudel shared that the previous executive committee (2016-2021) comprised of 13 members, with a gender composition of 54% male and 46% female (Figure 1). Social group representation was distributed as follows: 38% Brahmin-Chhetri, 46% Adivasi-Janajati and 15% Dalit. Notably, the key positions of Chairperson, Vice-Chairperson and Treasurer were all held by members of the Brahmin-Chhetri social group, while the Secretary belonged to the Adivasi-Janajati social group. This composition indicated a potential dominance of the Brahmin-Chhetri group in major decision-making and financial transactions. The Chairperson expressed satisfaction with regard to the level of women's participation in the previous committee. However, the nature of this participation is unclear and may have been exclusive.

With the pending official approval of the fifth revision of the Operating Procedures (OP), a unique opportunity emerges to establish a GESI-friendly executive committee for the next five years. This new committee should prioritize the inclusive participation of women

Infrastructure for eco-tourism in *Patle* CF. Photo: Author



Ethnic composition of *Patle* CF.

from all three major social groups – Brahmin-Chhetri, Adivasi-Janajati and Dalit – to ensure informed decision-making processes and transparent financial transactions. The proactive integration of GESI principles within the WEFE nexus offers significant value. By ensuring all voices are heard and needs are met in the management of these interconnected resources, a more just, equitable, and sustainable future for all can be achieved.

Synergy between the *Patale* CF and the WEFE Nexus

Sustainable Forest Management

Conserving forests safeguards water sources and ecosystem health. Community forests act as habitats for various species, maintaining ecological balance and environmental stability. Moreover, implementing sustainable forest management practices within the CF can contribute to carbon sequestration, soil health, and biodiversity conservation, aligning with the WEFE nexus goals.

Promote Renewable Energy

Beyond their ecological benefits, community forests hold significant potential for reducing dependence on fossil fuels by providing biomass for renewable energy generation.

Enhance Food Security

Sustainable forest management fosters diverse plant and animal life, contributing to food security and nutrition.

Time Savings for Women

The readily available firewood in the CF liberates women from member-households from the burdensome task of collecting wood, allowing them to redirect their time towards income-generating activities or personal development and education. With the newfound spare time resulting from improved firewood access via the CF, women have the opportunity to participate in eco-tourism initiatives (photo 3), fostering additional income generation and enhancing their overall well-being.

Trade-off within the *Patale* CF and the WEFE nexus

The existence of *Salla* trees in the *Patale* CF presents a complex trade-off within the WEFE nexus:

Groundwater Depletion

The presence of *Salla* trees in the *Patale* CF may contribute to groundwater depletion by impeding natural recharge, thereby posing a risk to the community's water security. This directly contradicts the WEFE nexus goal of ensuring sustainable water management.

Habitat Loss

Removing *Salla* trees could create space for preferred broadleaf species, potentially benefiting the overall ecosystem and biodiversity. However, it could also disrupt specific niche ecological communities reliant on *Salla* trees for survival.

Conclusion and Recommendations

The *Patale* CF exemplifies the power of community forestry in advancing the WEFE nexus. Through the integration of water, energy, food and ecosystem aspects, such initiatives hold promise for fostering a more sustainable and resilient future for both local communities and the planet as a whole.

To fully harness the potential of the WEFE approach in realizing sustainable development goals (SDGs), this case study recommends implementing targeted awareness programs at the grassroots level. By fostering an understanding of the interconnections between water, energy, food, and ecosystems, these initiatives empower local communities to

actively engage in SDG attainment. This approach fosters change, paving the way for communities to thrive in harmony with their local environment.

The WEFE approach, with its focus on community-driven awareness and action, has the potential to serve as a powerful catalyst for policy advocacy in Nepal, spanning all three tiers of government: federal, provincial and local.

This study recommends a comprehensive assessment to evaluate the harmonization between CFs and the WEFE nexus in 13 CFs (adjoining and neighboring to *Patale* CF) under the Mahalaxmi Sub-Division Office, *Lamataar*, Lalitpur at the landscape level. This landscape-level study will move beyond the "by default" integration of CFs and the WEFE nexus, adopting a "by design" approach to quantitatively measure synergies and trade-offs. By conducting this landscape-level analysis, policymakers can gain insights to craft well-informed policies and strategic interventions that optimize the role of community forests in achieving WEFE nexus goals.

Conclusion

Although all the case studies aim to show the connections between sectors and WEFE resources in various configurations, they were not originally designed with a WEFE approach in mind. When viewed through a nexus lens, several gaps can be identified that hamper the operationalization of the WEFE nexus approach on the ground. These gaps can be addressed through the application of WEFE nexus approaches and tools, which have proven effective. Some of these tools can be summarized below.

Identifying opportunities and bottlenecks for collaborative solutions involves integrating the WEFE nexus into existing planning processes to ensure coherence and synergy. Engaging stakeholders in a participatory planning and implementation process is vital for inclusive and comprehensive decision-making. Coordination and collaboration across various sectors and government scales are essential, including clarifying the roles of different agencies and actors involved. Establishing coordination mechanisms at various levels, such as a multi-stakeholder platform, can facilitate effective communication and cooperation among all stakeholders, ensuring that the WEFE nexus approach is effectively implemented and sustained.

Mapping inter-sectoral committees and programs/projects is crucial for understanding existing structures and identifying areas for collaboration. Similarly, assessing capacity gaps and developing capacity strengthening plans are vital for ensuring that stakeholders have the necessary skills and resources. Implementing a robust monitoring, evaluation, and learning plan fosters knowledge sharing, including best practices, through platforms and networks. Enhancing both vertical and horizontal coordination strengthens institutional capacity for coordinated decision-making. Promoting policy learning supports knowledge exchange and continuous learning, leading to improved governance and resource management.

Conflict resolution is essential for addressing competing interests through open dialogue and understanding. Utilizing digital sharing platforms can effectively communicate the complexity of the nexus to diverse stakeholders, enhancing engagement and collaboration. Implementing robust risk management strategies addresses uncertainties and attracts long-term investments. Coordinating with relevant stakeholders and ensuring clarity of roles and responsibilities, as well as equitable resource allocation, are crucial for optimizing resource use and achieving sustainable WEFE nexus outcomes. Finally, developing investment plans and financing mechanisms, such as the Public-Private-People Partnership model, ensures that projects are designed and funded using the nexus framework, promoting long-term sustainability and resilience.

By adopting a nexus lens and avoiding isolated sectoral solutions, unified and combined solutions can be crafted to address the challenges faced by WEFE sectors and actors. These include technical and engineering solutions to enhance infrastructure and operational efficiency, along with nature-based solutions that leverage ecosystem services and ensure environmental sustainability. Governance solutions are necessary to improve policy frameworks and institutional capacities. Gender equality and social inclusion responsive solutions ensure that all community members benefit equitably, focusing on the intersections between different conditions of marginalized communities in particular (for example gender, class, caste/ethnicity, geographic locations, etc.) who are heavily engaged in natural resources use and management. Additionally, market-based solutions can drive innovation and investment through economic incentives. Lastly, demand-based solutions tailor interventions to meet the specific needs and priorities of local communities, ensuring equity, effectiveness, sustainability, relevance, and resilience. Together, these diverse strategies create a comprehensive framework for overcoming challenges and achieving sustainable WEFE nexus outcomes.

For more information

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