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Trees outside forest for Chure dry land conservation in Makawanpur District, Nepal

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Abstract. *Bolakhe S, Ghimire P, Paudel P, Lamichhane U. 2024. Trees outside forest for Chure dry land conservation in Makawanpur District, Nepal. Intl J Trop Drylands 8: 106-113.* Trees outside forest (TOF) are considered as a potential strategy to meet the needs for timber, fuel wood, fodder and fruits of growing population and crop diversification to address land management problems and ecological concerns. In this backdrop, this study attempts to explore the contribution of TOF to Chure dry land conservation in Hetauda Sub-metropolitan City, Nepal. Field observation, household surveys (n=123), and in-depth discussions with local key informants were conducted to extract information about TOFs. The study documented 27 species of trees outside forest. About 19 species were present per household distributed on different locations like home gardens, terrace raisers, borderlands etc. More than 80% of these trees found on farmlands were planted, and only a few were naturally retained. Fruit trees (jackfruit and mango) dominated, followed by fodder (*Litsea* and *Ficus*) and other multipurpose species. Among the naturally regenerated trees, multipurpose species were abundant (>45%) and myriad fruit species (>60%) were seen among those planted. TOFs contributed to more than 40% of annual demands for fuel wood, fodder and bedding materials, whereas timber and poles are extracted in comparatively less amount. Almost all of the respondents agreed upon the positive impacts of TOFs on crop production, greenery enhancement and adaptation against drought. More than 90% of the respondents were positive about enhancing TOF for land productivity optimization and reducing pressure on forest to conserve fragile ecosystem of Chure dry land.

Keywords: Chure, dry land, ecosystem service, multipurpose tree, plantation

Abbreviations: ToF: Tree outside Forest

INTRODUCTION

Trees outside forest (TOF) are all trees that exist beyond the forest and other wooded land defined under the Forest Resources Assessment (FRA) by Food and Agricultural Organizations (FAO 2002). TOF may occur on agricultural land (such as meadows and pasture), built-up land (such as settlements and infrastructure), and barren land (such as sand dunes and rocky outcroppings) (FAO 2002). TOF offers a range of ecological, economic, social and religious functions (Pain-Orcet and Bellefontaine 2004; Tamang et al. 2019). These functions include carbon sequestration and other environmental services, resembling a win-win land-use strategy for climate change mitigation and adaptation, and ecosystem-based disaster risk reduction (Tamang et al. 2019; Peros et al. 2022; Liu et al. 2023).

The Chure region, also known as the Siwalik Hills, stretches over Nepal's southern belt and serves as an ecological transition zone between the lowland Terai and the Mid-hills (Singh 2017; FRTC 2022). It is one of the geographically young and fragile landscapes in Nepal and highly susceptible to environmental degradation due to its fragile geology, steep slopes, and high precipitation variability (Bishwokarma et al. 2016; Singh 2017). Over the years, unsustainable practices like overgrazing, illicit logging, deforestation, and unregulated sand mining have all contributed to the region's vulnerability, resulting in significant soil erosion, landslides, biodiversity loss, and depleted water resources (Singh 2017; FRTC 2022). high dependence of more than 80% of communities on forest and agriculture for livelihood further exacerbates the condition of the fragile ecosystem in this region (Bishwokarma et al. 2016; Singh 2017). These issues have had a cascade effect on local livelihoods, agriculture, and ecosystem services, making the Chure region an important conservation target.

Trees in agricultural landscapes have massive, yet unexploited, potential benefits to people and environment. On the one hand, it plays an important role in sustaining and restoring the physical environment, particularly by enriching soil fertility, reducing erosion, improving air and water quality, enhancing biodiversity and sequestering carbon (Pain-Orcet and Bellefontaine 2004; Prevedello et al. 2018; Tamang et al. 2019). On the other hand, it serves as source of livelihood for rural household economy by producing food, fuel and fodder (Pain-Orcet and Bellefontaine 2004; Ghimire et al. 2020; Lamichhane and Ghimire 2023). In the dry and fragile landscape, systematic management and fostering of non-forest trees could considerably contribute to increasing tree carbon stocks and landscape diversity (Prevedello et al. 2018; Peros et al. 2022). TOFs are crucial for conserving land in dry areas,

where natural forests are scarce or absent (Liu and Slik 2014; Fremout et al. 2020; Peros et al. 2022). They stabilize soils, improve water retention, and enhance ecosystem resilience. TOFs anchor the soil, reducing wind and water erosion, and maintaining land fertility (Fremout et al. 2020). They improve the microclimate by providing shade, lowering temperatures, and reducing soil moisture evaporation, leading to higher agricultural productivity (Liu and Slik 2014; Yadav et al. 2017; Fremout et al. 2020). Trees facilitate water infiltration, allowing groundwater recharge, and sustaining ecosystem functions and livelihoods (Liu and Slik 2014; Fremout et al. 2020; Pati et al. 2022). TOFs also promote biodiversity in dryland ecosystems, providing microhabitats for various species and serving as windbreaks to protect crops and soils from strong, dry winds.

In recent times, policymakers have also recognized the significance of trees outside forests in achieving sustainable development and food security (Schnell et al. 2015; Lohbeck et al. 2016). The recognition of TOF is important to acknowledge their role in human livelihoods, environment and biodiversity (FAO 2002; Pain-Orcet and Bellefontaine 2004; Yadav et al. 2017; Prevedello et al. 2018; Peros et al. 2022). To enhancing the contribution of tree outside the forest to sustainable livelihoods, several reports and case studies were conducted (e.g. FAO 2002; Rawat et al. 2003). Recently, the increasing interest in global issues like climate change mitigation, carbon sequestration, and poverty alleviation makes TOF even more important. However, more research is needed to understand their state and influence on biodiversity conservation over time, as trees grown in non-forest areas are essential components of planning and development policies (FAO 2002).

In Nepal, trees outside forest area contribute significantly to sustainable development and people's livelihood. However, the primary focus has always been on trees in the forests, which are viewed as a resource and a repository of biological diversity (FAO 2002; Giri 2017; Ghimire and Bolakhe 2020). Despite their potential, the management and promotion of TOFs in Nepal remain underexplored. Furthermore, TOF have not been included in the national forest inventory, despite the fact that they serve a variety of functions for human well-being and environmental conservation (Oli 2017; Ghimire et al. 2020). TOF provides various environmental, economic, and socio-cultural services and functions, but people are not fully aware and benefit from these services because TOF is neither well documented nor given enough attention in Nepal. Recent policies and initiatives from the government aims at reducing pressure on forest and thereby developing ecosystem beyond forest areas. Given the critical importance of conserving the Chure region, this study highlight the pivotal role of TOFs in addressing both environmental and socio-economic challenges. It explores the role of TOFs in stabilizing the Chure region's ecological integrity while ensuring socio-economic benefits for communities.

MATERIALS AND METHODS

Study area

This study was conducted in Ward no. 16 of Hetauda Sub-Metropolitan City, Makwanpur District, Bagmati Province, Nepal (Figure 1). It covers 18.95 km^2 area and consists of 1228 households. The study area lies in the Chure region of Makwanpur District and is geographically situated at 27°25' N and 85°02' E at 300-390 masl. Covering about 12.78% of the total land mass of the country, Chure region is a critical ecological region in Nepal, providing a buffer zone for the fragile ecosystems of the southern Terai and northern mid-hills (FRTC 2022). This is an environmentally sensitive region characterized by fragile geology, deforestation, and soil erosion. Human-induced activities like overgrazing, unsustainable farming, and illegal logging have intensified the vulnerability of the Chure. This biologically rich but geologically fragile region is the home to many species and provides many ecosystem services to millions of people (Hetauda Sub-Metropolitan City Office 2018; FRTC 2022). The study area harbors globally importance biodiversity with diverse community and provides ecosystem services that support the socio-economic well-being of people and development in Chure region of Nepal. The extent and scale of the landscape also allow for assessing TOF for climate change adaptation strategies (Bishwokarma et al. 2016).

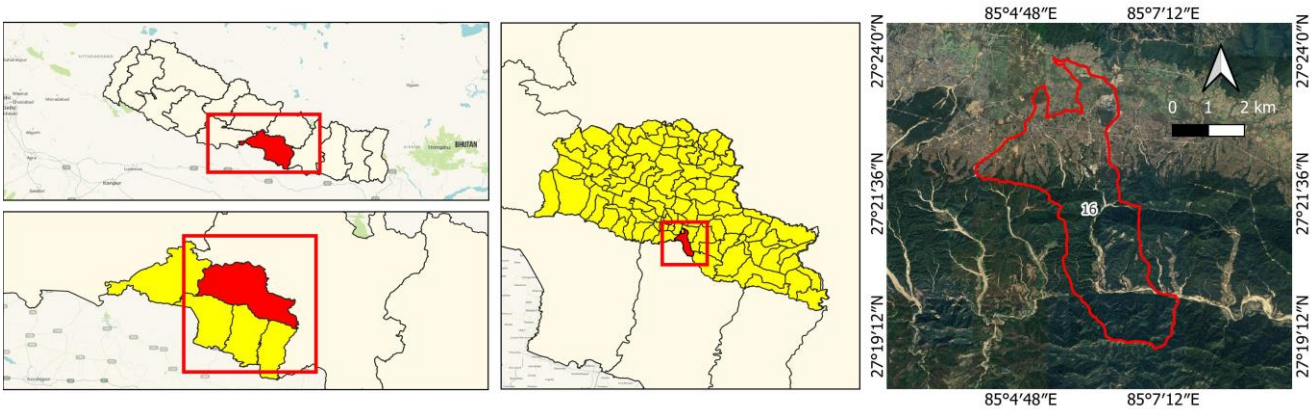

Figure 1. Map of the study area in Ward no. 16 of Hetauda Sub-Metropolitan City, Makwanpur District, Bagmati Province, Nepal

Sampling design and data collection

Simple random sampling with 10% sampling intensity was taken for the collection of data. Both qualitative and quantitative data for this study were collected. A total of 41 circular plots of size 1,000 m^2 having radius of 17.84 m were laid out randomly to collect tree species abundance. Socio-economic and ecological importance of TOF was assessed by applying various practical approaches in order to bring the realistic and acceptable role of TOF for extension to local level. Semi-structured questionnaire survey (n=123), and focus group discussion (n=3) with key informants and ward executive committee members were used to collect the socio-economic and ecological importance of TOFs. The secondary data required were extracted from the Hetauda Sub-metropolitan City Office profile (Hetauda Sub-Metropolitan City Office 2018).

Data analysis

The total 123 households sampled for this study had 90% CI and 10% margin of error. The information gathered from both primary and secondary sources was analyzed using Statistical Package for Social Science (SPSS) and presented in tables, figures and bar charts, etc.

RESULTS AND DISCUSSION

Number of species and abundance

In total, 27 species of trees outside forest were recorded in this study (Figure 2). Among these, *Artocarpus heterophyllus, Melia azedarach, Litsea polyanthus, Dalbergia sissoo, Shorea robusta* and *Tectona grandis* were the species with higher frequency. Ghimire and Bolakhe (2020) and Lamichhane and Ghimire (2023) reported 71 and 63 species in the farmlands of Makawanpurgadhi rural municipality and Bhimphedi rural municipality respectively, in Makawanpur District, Nepal. The variation in the number of species can be attributed to the change in the physiographic zones, and within a given physiographic zone, it varies with location. Similary, Paudel et al. (2019) reported 32 tree species in the agroforestry land of Likhu rural municipality in Dolakha District, Nepal. A total of 1252 trees belonging to 85 species, 73 genera and 38 families were recorded in outside forest area in central India (Pati et al. 2022). The presence of wide diversity of tree species shows that area outside of forest or farmlands are good repository of high floral diversity (Marchetti et al. 2018; Tamang et al. 2019; Bhandari et al. 2021).

Regeneration mode and tree location

The presence of trees outside forest in the study area was originated from planting and naturally regenerating (Figure 3). More than 80% of these trees found on farmlands were planted, and only a few were growing naturally. Planting was the most preferred method to grow fodder and fruit species in borderland, farmland, and home garden whereas natural regeneration occurred in trace raiser and dikes. Natural regeneration was done mostly for slope stabilization and soil conservation purposes. Ghimire et al. (2020) also found that trees in farmlands, fallow lands and borderlands in Sindhupalchok District, Nepal mostly raised in terrace raiser. On the other hand, a study by Paudel et al. (2019) found that tree species planted were commonly on farmlands and home gardens.

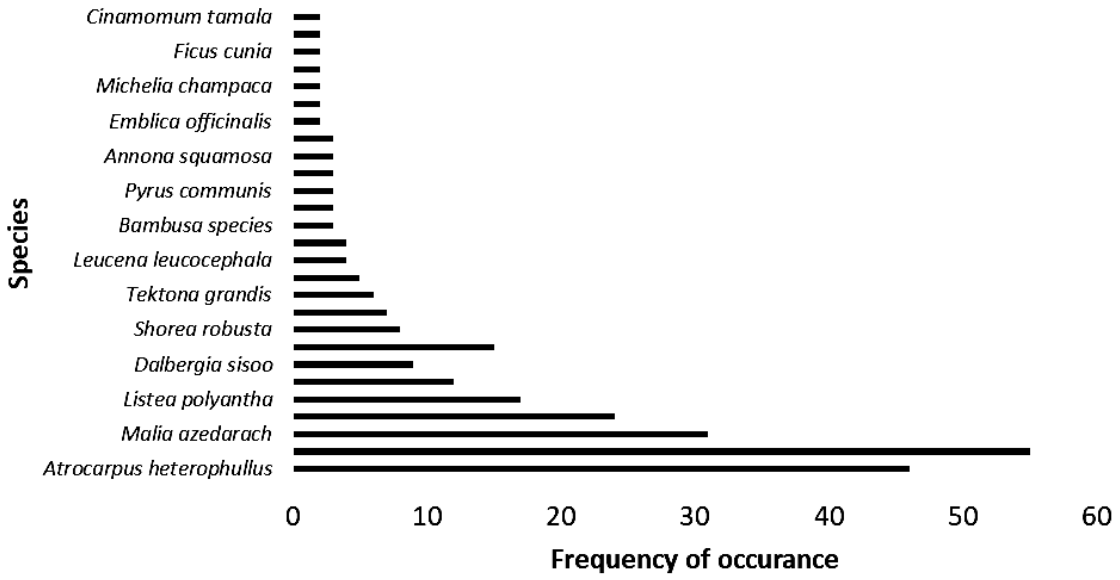

Figure 2. Tree species and its abundance across the sampled plots in Makwanpur District, Bagmati Province, Nepal

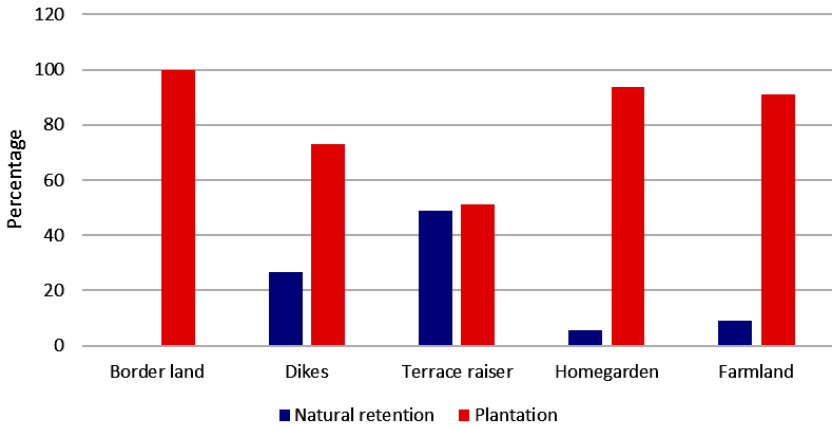

Figure 3. The proportion of trees outside forest based on the location and mode of regeneration

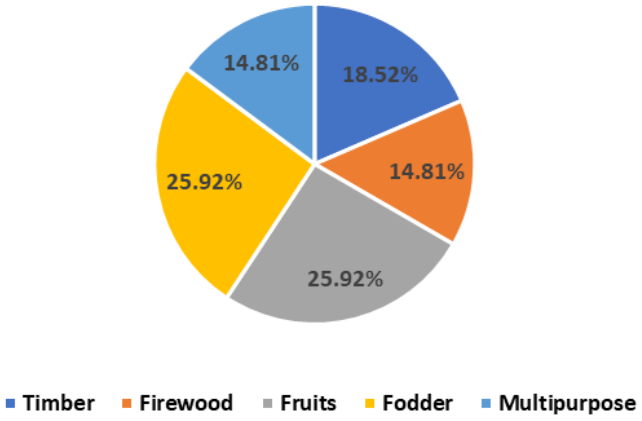

Figure 4. The proportion of trees outside forest based on the uses by community

Uses of tree species

Fodder, fruits and timber tress were the dominant tree species in the study area. Fodder species like *Litsea monopetala*, *Ficus* spp. dominated the composition with 25.92%, followed by *Shorea robusta* and *Tectona grandis* (18.52%) and other multipurpose trees like *Melia* (14.81%) (Figure 4). Species like *Ficus bengalensis*, *Ficus religiosa*, *Nyctanthes arbor-tristis* and *Elaeocarpus sphaericus* were also available in noticeable amount. This shows that people especially like to grow fodder trees on their farmland in order to fulfill their livestock needs and diet. Amatya et al. (2018) highlighted that trees in farmland are mainly multipurpose and choices are governed by primary household needs, such as timber, firewood and fodder.

The use value of TOFs goes beyond their ecological role, providing significant socio-economic and environmental benefits. TOFs, which can be found in agricultural landscapes, urban areas, along roadsides, and around homesteads, directly benefits the livelihoods of both rural and urban communities (Pati et al. 2022; Peros et al. 2022). These trees provide products such as fodder, fuelwood, fruits, timber, and medicinal plants, which support local economies and household needs. Furthermore, TOFs improve ecosystem services by enhancing soil fertility, sequestering carbon, regulating water cycles, and offering shade and shelter. TOFs improves urban aesthetics, reduce air pollution, lower temperatures, and promote mental well-being by enhancing green spaces (Ghosh et al. 2019; Pati et al. 2022; Peros et al. 2022). Their versatility and accessibility make TOFs critical in enhancing the resilience of both rural and urban populations to climate change and economic challenges.

Number of trees and landholding

Figure 5 presents the relation between land holding (ha) and number of trees per household. It was found that with increase in area, number of trees are increasing but there is no strong relationship between them. This signifies that tree in private land is either depends in family living standard or types of land they hold. Figure 6 shows the relationship between a number of livestock and the number of trees. This also shows no significant relationship between them, but there is a slight increase in trend, i.e., when the number of live stocks increases, trees also increase.

Goods and services provided by TOF

In addition to its function in farmland, TOF are considered important in term of delivering ecosystem goods services. Different provisioning and regulating services from TOF were recorded in the study area, including major provisioning services of timber products, poles, firewood, fodder, and bedding materials. About 40% of annual demand for bedding materials, fodder and fuel wood was fulfilled by TOF whereas timber and poles were extracted comparatively in less amount (Figure 7). The contribution to timber annual supply from TOF was also significant. This shows that TOF is reducing pressure on forests and can be promoted as alternative forest product supply measures.

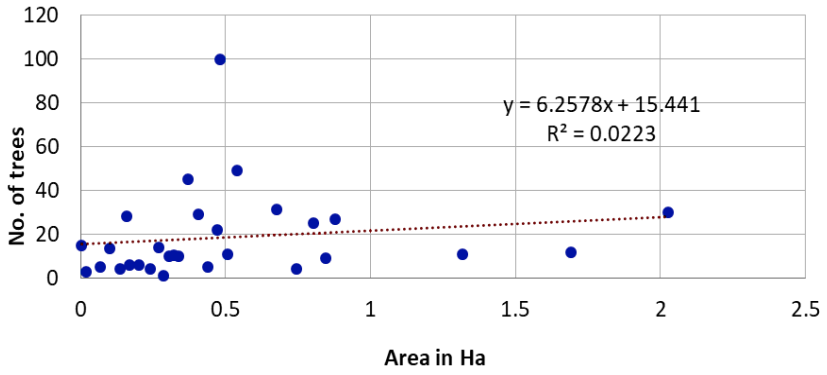

Figure 5. The relationship between the number of trees outside forest and extent of landholding

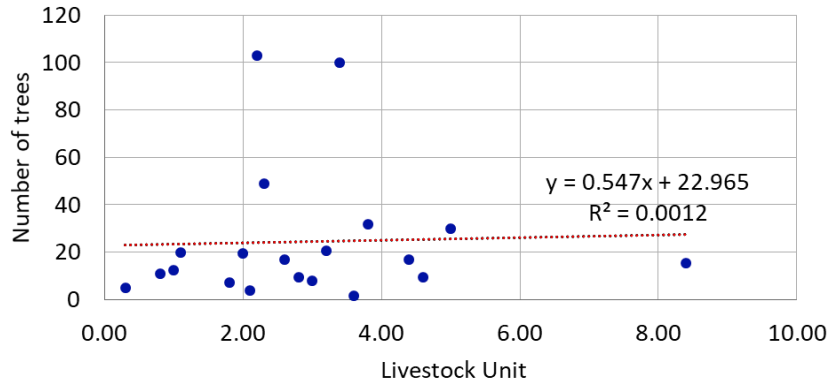

Figure 6. The relationship between the number of trees outside forest and the number of livestock units

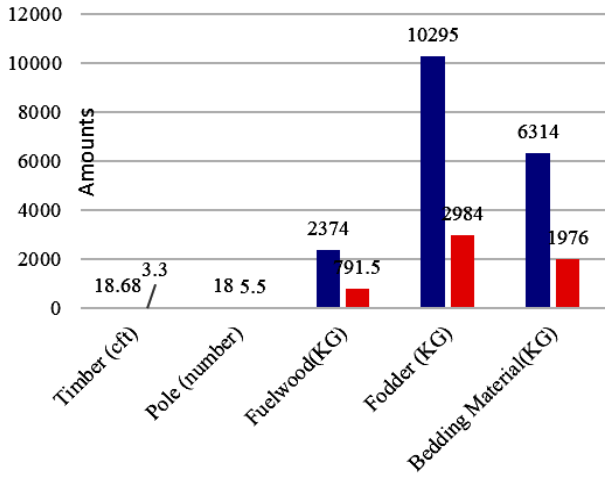

Figure 1. Provisioning goods and services from trees outside forest and its contribution to livelihoods

Similarly, seven regulating services were recorded in study area (Figure 8). People believe that TOF primarily helps with soil conservation, erosion control, slope stabilization, and flood control which directly helps to stabilize Chure Hill. While, other services like water quality improvement, habit improvement and carbon storage also signified the importance of TOF.

TOFs can produce wide range of products and services (Tamang et al. 2019; Peros et al. 2022). Trees in and around farmlands produces products like timber, firewood, fruits, fodder medicines etc. (Ghimire et al. 2020, 2024) which can directly be traded. Whereas, services like reducing soil erosion, stabilizing slope, maintaining soil fertility, minimizing drought, improving water table and working as windbreaks are more valuable to maintain biodiversity (Lasco et al. 2014; Varma et al. 2023; Ghimire et al. 2024) and to mitigate the impacts of climate changes for mountainous communities. There has been increasing accumulation of evidence that supports the ecosystem services and environmental benefits claims of TOF including agroforestry systems in both the tropical and temperate regions (Guo et al. 2014; Lohbeck et al. 2016; Ghosh and Sinha 2019). Ghimire et al. (2020) highlighted the significant value of TOFs for the maintenance of both provisioning and regulatory services in Sindhupalchok District, Nepal. Furthermore, a study by Baral et al. (2013) in Kanchanpur District of Nepal supports the significant importance of TOF for provision of ecosystem services and biodiversity conservation. In recent decade, TOF are becoming critical for ecosystem services and economic benefits, such as potential contribution to agriculture, food supply and income through the provision of goods and services, conservation of biodiversity and carbon sequestration (Chakravarty et al. 2019).

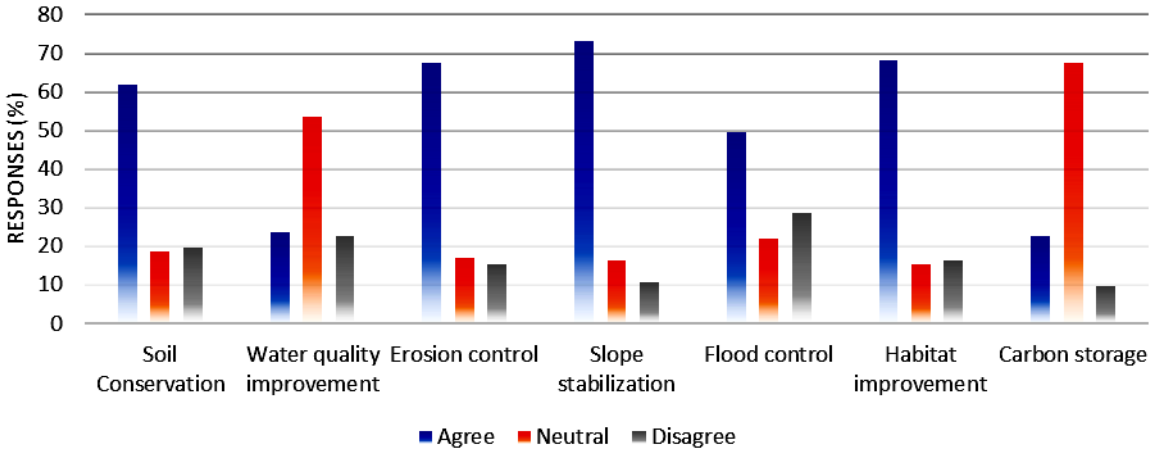

Figure 8. Regulating services from trees outside forest perceived by the respondents

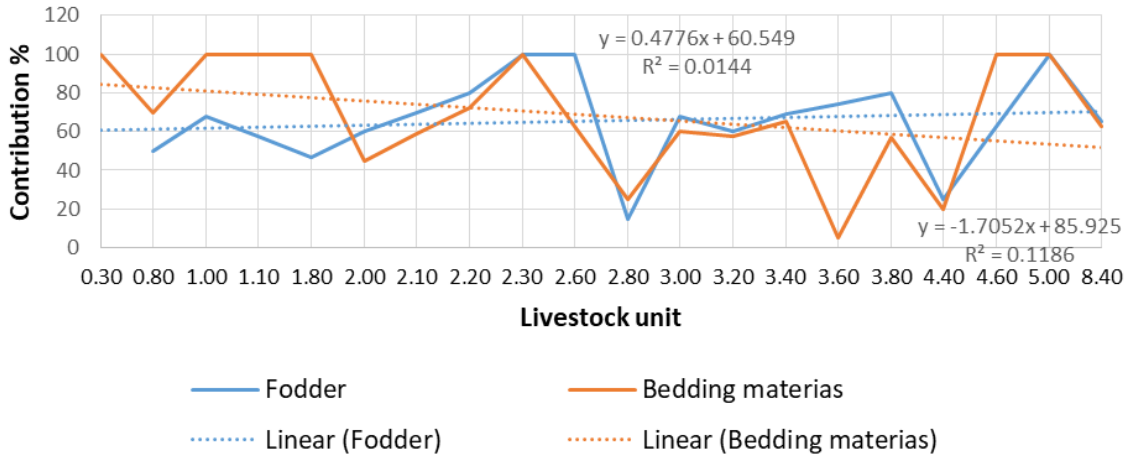

Figure 9. The contribution of trees outside forest for fodder and bedding materials and its relationship with livestock unit

Contribution of TOF to livestock production

Figure 9 shows the relation between livestock units and the contribution percentage of TOF. It shows that with increase in livestock unit, TOF contribution to fodder supply is also increasing. This is mainly due to fodder trees like *Leucaena leucocephala*, *Litsea monopetala* and *Ficus lacor*, resulting in the decreasing of the contribution to bedding materials. It is also clear that TOF is contributing to reducing pressure on forests. Amatya et al. (2018) highlighted that forestry sector contributes to 40% of the livestock fodder consumption in Nepal. Tree-growing practices in and around homesteads and farmland have long been associated with rural Nepal, and are thus regarded as integral components of rural livelihoods (Giri 2017; Oli 2017). TOFs have been found to be economically and environmentally sustainable both at small and large scales. Farm trees and home gardens are major sources of fodder for livestock in rural landscape (Rossi et al. 2016; Jose et al. 2019; Lamichhane and Ghimire 2023).

Promotion of tree outside forest

The existence of trees in farmland is a part of traditional as well as contemporary farming systems in rural areas of both developed and developing countries. It is well known that TOF offers a range of ecological, economic, social and religious functions to conserve biodiversity and to uplift the local people livelihood. During the study, more than 90% of the respondents were positive about enhancing TOF for land productivity optimization and reducing pressure on forests to conserve the fragile ecosystem of Chure region (Figure 10). Hence, the importance of TOF to conserve biodiversity by reducing the pressure on forest resources could be recognized both at national and international level.

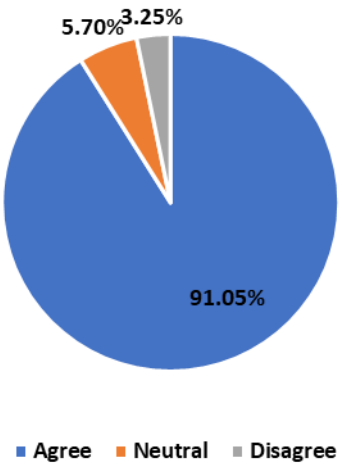

Figure 10. Respondents' perception on the promotion of trees outside forest for Chure conservation

People believe that to conserve Chure region, activities should be separated into two part: activities inside forest and outside forest. In-situ activities, like tree planting, reducing grazing and logging along with proper infrastructure development activities, promotion of TOF, education and alternative job opportunities can significantly reduce the pressures on Chure forest (Bishwokarma et al. 2016; Singh 2017). People believe that promoting TOF helps to conserve Chure by reducing the pressures for fodder, fuel wood and timber (Bishwokarma et al. 2016; Singh 2017; Bhandari et al. 2022). Proper research to recommend species based on major agriculture crops is urgent.

In conclusion, the importance of trees outside forest for dryland conservation is undeniable, as they play a critical role in sustaining ecosystems and supporting human livelihoods in fragile environments. This study focuses on the multifunctional benefits of trees outside forest in drylands, where their presence is critical for reducing land degradation, improving soil fertility, and enhancing water retention. TOFs act as natural windbreaks, reducing soil erosion and protecting agricultural crops from harsh climatic conditions. They also provide essential products such as fuelwood, fodder, and food, which are crucial for the survival of rural. Moreover, TOFs helps to conserve biodiversity by offering habitat and food sources for wildlife. Their ability to sequester carbon and regulate microclimates aids in mitigating climate change. Therefore, TOFs could be a viable option for conserving Chure dry land by balancing biodiversity conservation and production. The local community also recommended using TOFs as a significant approach to conserve Chure region. Integrating TOF into Chure dryland management strategies is critical for promoting environmental sustainability, enhancing agricultural productivity, and strengthening the resilience of communities living in the Chure area. This study highlights the importance of policies and practices that promote the sustainable management and expansion of TOF in Chure conservation efforts.

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