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IMPORTANCE OF TREES OUTSIDE FOREST (TOF) IN NEPAL: A REVIEW

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Abstract: Trees outside forests (TOFs) are important natural resources that contribute substantially to national biomass and carbon stocks and to the livelihood of people in many regions of the world. Over the last decades, decision makers have become increasingly aware of the importance of TOF, and as a consequence, this tree resource is, nowadays, often considered in forest monitoring systems. TOF in Nepal's *Terai* have significantly increased over the past decade. Despite the important role of TOF in subsistence and market-based rural livelihood diversification, and the consequent reduction in pressure on national forests from on-farm trees, current government policies and practices fail to recognize the value of these trees. A responsive service mechanism centered on tree growing households would help the management of tree resources on the farmland. Numerous studies have been conducted on assessment of carbon, biodiversity and livelihood. However, a knowledge gap exists regarding TOF resources at the rural level related to policy in particular. TOF have good potential for sequestering atmospheric carbon and enhancing plant biodiversity. The private sector has a significant role in promoting TOF in the form of on-farm trees, agroforestry and others non-wooded land management. The government's role has not been satisfactory for enhancing TOF. Therefore, TOF and its management should be given high priority for bio-diversity conservation, carbon sequestration and promoting rural livelihood.
Keywords: Agroforestry, Carbon sequestration, Rural livelihood, Tree biodiversity.
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INTRODUCTION

In human-influenced landscapes where ecological conditions are favorable to tree growth, trees can be found in a wide range of situations and spatial patterns. The concept of Trees outside Forests (TOF) emerged in 1995 to designate trees growing outside the forest and not belonging to forest or other wooded land. The term represents an effort to concentrate attention that had been spread out on components of this rather diffuse resource: agroforestry, silvopastoralism, urban and rural forestry, and other related disciplines. In policy and public discourse, these important resources were overlooked. FAO (2010) made some criteria to define a forest *i.e.* land spanning more than 0.5 Ha. with trees higher than 5m and a canopy cover of more than 10%, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. TOF are trees that do not fulfill the criteria of forest, so the TOF realm depends on the definition used for forest in any country or agency conducting an assessment. TOF can be found in all climates, land types, land uses and regions. They ensure a multitude of ecological, economic, social, and cultural functions that in many cases are vital for human livelihood. TOF are high potential for storing the valuable vegetation carbon and plant biodiversity (Kharal and Oli, 2008; Mandal *et al*., 2014). TOF have important economic, social and environmental implications, at local, national and international scales.

In the current context of change, their importance will increase dramatically for people's livelihoods and national economies, and also for various international processes that address global environmental and economic challenges: carbon sequestration, biodiversity loss, desertification, poverty alleviation (Hubert et al., 2013). Pandit *et al.* (2013) stated that TOF have the potential to offer multiple benefits, great opportunities for increasing the contribution (decreasing negative effects of climate change and increasing farm income) from agroforestry through farmers' income in mid-hills of Nepal. Shrestha (1996) described the changes to the farming systems to increase tree planting on farmland. The consequences are reducing the pressure on natural forest in one way and carbon enhancement and species diversity in other way (Singh *et al.,* 2009, Thompson, *et al*., 2009). This meets the important goal of the Reducing Emission from Deforestation and Forest Degradation (REDD+) mechanism.

Many study reported that TOF are increasingly recognized as a prominent feature of either agricultural lands or built-up areas (Bellefontaine *et al*., 2001; Gutzwiller 2002; Konijnendijk *et al.* 2005; de Foresta *et al*., 2013). In agricultural landscapes, TOF are often referred to as scattered, isolated or paddock trees (Manning *et al.*, 2006; Gibbons *et al.*, 2008). In cities and towns, TOF are street and roadside trees, trees planted in parks, gardens and private yards (Tyrvainen *et al*., 2005; Wu, 2007). Not much is known, however, about the drivers of TOF spatial distribution either in urbanized or in agricultural landscapes since they are generally absent from forest inventories (Rossi *et al*., 2016). TOF are trees on land not defined as forest and other wooded land, a definition that is dependent on how forests and woodlands are defined themselves (Kleinn 2000; de Foresta *et al*., 2013). TOF is defined as all those trees, which have attained 10 cm or more diameters at breast height, available on land, which is not notified as forests (FSI, 2011). Though, there is no any legal definition of TOF in Nepal, it includes the tree in other wooded land than the forest (DFRS/FRA, 2014).

Typology of Trees Outside Forest

Review from the past study showed that there are three major and distinct TOF sets collectively make up the TOF realm (FAO, 2012): TOF on agricultural land, TOF on urban land, and TOF on non-urban and non-agriculture land.

TOF on Agriculture Land: It includes all lands predominantly under agricultural use with trees and/or shrubs whatever their spatial pattern (in line, in stands, scattered), irrespective of area, height, strip width, and canopy cover level. It includes all agroforestry systems except those which main purpose is forestry; it includes also all non-forestry tree crop plantations and orchards.

TOF on Urban Land*:* It includes all lands predominantly under urban use with trees and/or shrubs whatever their spatial pattern irrespective of area, height, strip width, and canopy cover level. It includes trees in private gardens, in parks, along streets, in parking lots and others.

TOF on Non Agricultural/Non-Urban Land: It includes all lands not predominantly under agricultural or urban use, and outside forests.

By definition all trees and/or shrubs on agricultural land and on urban land are TOF, irrespective of plant height, patch area, width or canopy cover. Trees on agricultural land and on land under urban use may be planted or not, and may occur with various densities and under various spatial patterns.

Scope and importance of Trees Outside Forest

TOF provide various ecosystem services such as control over soil erosion, nutrient and water cycling, biodiversity conservation or pest control (Plieninger *et al.*, 2004; Lumsden and Bennett 2005; Manning *et al*., 2006). Urban woods and isolated trees also provide important social, aesthetic, and economic benefits (Tyrvainen *et al.* 2005; McDonnell *et al.* 2009). TOF are also used as a source for food (Herzog, 1998), fodder (Hinsley and Bellamy, 2000), and wood products (Ahmed, 2008; Pandey, 2008). For many societies, the cultural value (Grala *et al.*, 2010) and scenic or recreational uses are of great importance (Herzog, 2000). Even in urban environments carbon sequestration can be substantial (Nowak, 2002) in addition to other services like regulation of micro-climate (Bowler *et al.*, 2010) and removal of air pollutants (Jim and Chen, 2009).

The potential for carbon sequestration through TOF can thereby be considered to be high, in particular for agroforestry systems with a rather dense canopy cover (IPCC, 2000). In addition, important co-benefits, such as erosion control (Baudry *et al.*, 2000; Manning *et al.*, 2009) and the conservation and improvement of biological diversity (Paletto and Chincarini, 2012; Bhagwat *et al.*, 2008) can be obtained. From a climate change perspective, TOF are seen as a mitigation strategy because additional tree plantings on agricultural and urban lands for carbon sequestration normally do not compete with other land uses (Schoeneberger, 2009; Plieninger, 2011; Schoeneberger *et al.*, 2012). The potential for carbon sequestration through TOF can thereby be considered to be high, in particular for agroforestry systems with a rather dense canopy cover (IPCC, 2000). In addition, important co-benefits, such as erosion control (Baudry *et al*., 2000; Manning *et al.,* 2009) and the conservation and improvement of biological diversity (Bhagwat *et al*., 2008; Paletto and Chincarini, 2012) can be obtained. TOF are also used as a source for food (Herzog, 1998), fodder (Hinsley and Bellamy, 2000), and wood products (Ahmed, 2008; Pandey, 2008). For many societies, the cultural value (Grala *et al*., 2010) and scenic or recreational uses are of importance (Herzog, 2000). Even in urban environments carbon sequestration can be substantial (Nowak, 2002) in addition to other services like regulation of micro-climate (Bowler *et al*., 2010) and removal of air pollutants (Jim and Chen, 2009).

In many developing countries of Asia and Africa, forests and trees have been an integral part of subsistence farming systems. Such trees add diversity and help sustain the farming system and rural household economies (Nair, 1993; Arnold, 1997; Garforth *et al*., 1999). Trees, agriculture, and livestock are interlinked in the Nepalese farming system and thus the sustainability of this farming system depends on the continuous existence of tree outside resources (Gilmour, 1997; Regmi, 1998; Garforth *et al*., 1999). Agroforestry systems which include trees and shrubs are an important component of rural farming systems in Nepal (Baral *et al.,* 2013) and are mostly considered TOF because of the predominant agricultural land use; however, cases exist where a forest land use dominates. In addition, TOF is increasingly viewed as an avenue for biodiversity conservation, carbon sequestration, climatic stabilization and livelihood support in rural and urban areas (Pandey, 2002; Acharya, 2006). Bellefontaine *et al*., (2002) have reviewed and documented the backlog of knowledge concerning TOF with cases studies from different continents and called for holistic management approach of resource management at local, regional and global scale. TOF resources outside public and private forests have helped alleviate pressure from national forests and made significant positive contributions to conservation of biodiversity (NBSAP, 2014).TOF is the major source of timber and firewood for farmers (Longi *et al.,* 1999, Singh *et al*., 2012) living distant from the forests in Terai (plain) Nepal, because they have no enough and easy alternatives to meet their demand of forest products. The consequences are reducing the pressure on natural forest in one way and carbon enhancement and species diversity in other way (Singh *et al*., 2009, Thompson, *et al*., 2009). This meets the important goal of Reducing Emission from Deforestation and Forest Degradation (REDD+) mechanism. Sustainably managed non-forest land has the potential to bring multiple benefits for farmers. Thus, there are great opportunities for increasing the contribution (decreasing negative effects of climate change and increasing farm income) from agroforestry (Pandit *et al*., 2013). DFRS/FRA/Nepal Main Report (2016), forest occupies a total of 5.96 million ha in Nepal which is 40.36% of the total area of the country. Other Wooded Land (OWL) covers 0.65 million ha (4.38%). Forest and OWL together represent 44.74% of the total area of the country (DFRS/FRA, 2015).

Methodology

This paper is based on a review of existing literature. The collected documents were reviewed and categorized into carbon stock, biodiversity and livelihood promotion. The primary purpose of this manuscript is to show the relationship between TOF and carbon stock, biodiversity and livelihood in the Nepalese context.

Carbon Stock Dynamics in Tree Outside Forests

Forest vegetation and soils constitute a major terrestrial carbon pool with the potential to absorb and store carbon dioxide (CO_2) from the atmosphere. The CO_2 source and sink dynamics as trees grow, die, and decay are subjected to disturbance and forest management. The world's tree resources have a substantial role in the global carbon cycle. Although tree resources are mainly associated with the forest area, generally there is an extensive tree wealth exists outside continuous forested areas in every country (Heyojoo and Nandy, 2015). They make a critical contribution to sustainable agriculture, food security and rural household economies; they supply many products and services similar to forests; and they protect crops and the soil against water and wind erosion, thus combating drought and desertification and protecting water resources. Also, they embrace many ecological functions like conservation of biodiversity and carbon sequestration (Schroeder 1994; Rawat *et al.* 2004; FAO 2005). The phytomass of trees is useful for timber resources, forest management, nutrient cycling, and CO_2 sink (Brown *et al.* 1989; Silva *et al.* 1993; Foody *et al.* 1996). Vegetation or plantation provides one of the natural ways of cleansing the atmosphere by absorption of gaseous and some particulate matter through leaves (Varshney, 1985). Plantations with pollution trap species along the linear features (such as roadside, canal side) and in the form of green-belts and agroforestry in urban periphery is one of the potential alternatives to mitigate air pollution as plants produce oxygen, serve as a sink for pollutants, and also check the flow of dust and fly-ash to the areas of human settlements and bring down noise pollution level (Rawat *et al.* 1998). Agrawal and Tiwari (1997) have studied the tolerance of species for the abatement of air pollution. The study has found that *Albizzialebbek, Ficusgibbosa syn. Ficustinctoria, Terminaliaarjuna*, and *Madhucalatifolia*are found to be good for the abatement of air pollution.

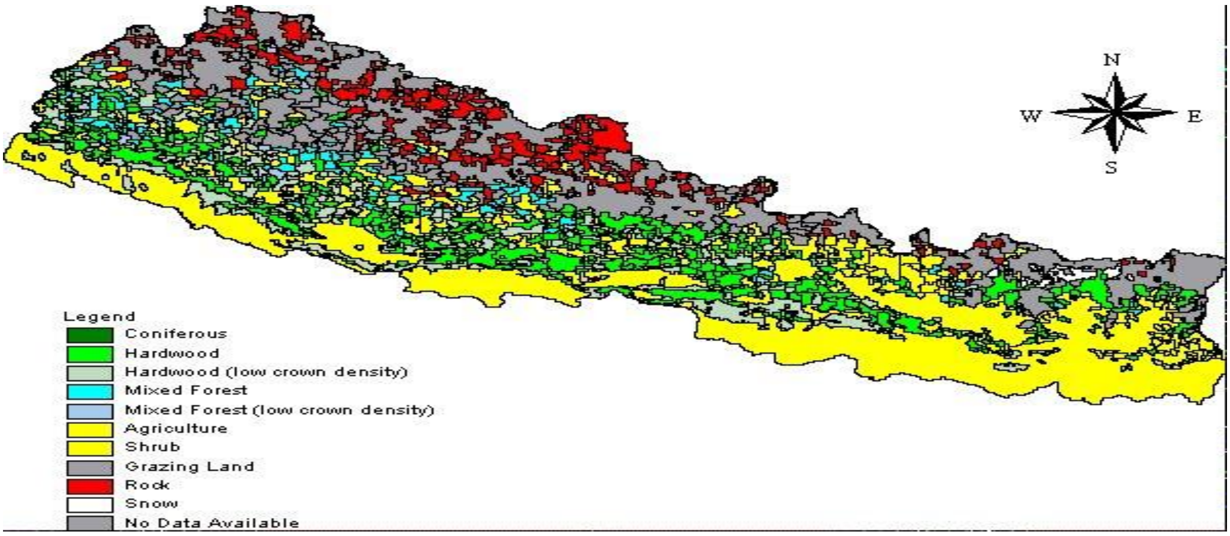

Figure 1. Map of Nepal showing forest cover

TOF play an important role in both the sequestration and storage of carbon. Not only do theystore substantial amounts of carbon in live biomass but also cause a local increase in soil organiccarbon (Follain *et al.,* 2007).Thus, the reliable information on TOF presence, spatial distribution, type, quality, and temporal changes is needed, particularly in the larger areas where forest cover is very less such as provinces, countries or regions (FAO ,2005). According to the IPCC GPG (Intergovernmental Panel on Climate Change, Good Practice Guidance 2004), remote sensing methods are especially suitable for quantification of aboveground vegetation biomass stocks and associated changes. Patenaude *et al.* (2005) have reviewed the applicability of different optical and microwave remote sensing techniques in the forest carbon estimation in relation to the 'Kyoto Protocol'. Impetus has been given to areas adjacent to the road/highway, barren lands, and farm forestry plantations. The status of TOF would also indicate the success of afforestation projects such as social forestry and wasteland development in many countries. As information on TOF is mostly absent from official statistics, policy initiatives for its management is also hurdled with time consuming methods of age old inventorying. Although, there are a number of studies which mainly concentrate on the mapping and quantifying the deforestation, biomass and carbon content estimation in forest area, very few are concerned about the fate of land formerly under forest and the tree wealth outside the forest area or on farmlands. Similarly, little is known about changes in tree cover in fields and urban systems (FAO, 1999). For many developing countries where carbon database is either not available or incomplete, remote sensing coupled with ground-based observations can be used not only to generate and disseminate the carbon information but also pinpointing the potential locations for generating carbon credit pools (Kale *et al.,* 2002). There are a number of studies carried out on TOF resources from the last decades worldwide. De Gier *et al.,* (2001) modeled the above-ground woody biomass assessment (fresh weight, volume, dry weight) of TOF using field data collected in three Central American countries (30–45 trees per study site). Koukal and Schneider (2003) developed automatic algorithms in order to classify TOF on satellite imagery. In India, Forest Survey of India (FSI) has been engaged in assessing the TOF wealth of the country since 1991 (Rawat *et al.* 2004).

Globally, estimated annual net change of forest area was -5.2 million ha between 2000 and 2010. Similarly, there were more than 0.9 million ha forest area shrink in Southeast Asia in the last 10 years (FAO, 2010) and the estimated annual deforestation was 84,000 ha in Nepal between 1991 and 2001 (DOF, 2005). The depletion in forest negatively effects on carbon stocks and biodiversity together (Sedjo, 2001). Plantation in trees outside forest has been playing positive roles in carbon enhancement and biodiversity conservation (Leah *et al*., 2010) in Nepal. Total global plantation area was estimated 264 million ha in 2010 which has capacity to store about 1.5 gigatonnes of carbon annually. Particularly, almost half of the agricultural land has tree cover of more than 10% in the world (more than 1 billion ha), they are TOF. Net gain of forest was reported more than 2.2 million ha per year in Asia in between 2000 to 2010 because of large-scale of afforestation in China (FAO, 2010). Though, there was no clear record of TOF in Nepal but mostly the private plantation is considered as TOF. Estimated record of TOF was 10,240 ha in the country (DOF, 2005). These all plantations offer to store the carbon and ultimately support to ease the people's pressure on national forests (Gibbs *et al.,* 2007), this concept is aligned with the main purpose of REDD+ mechanism (Skutsch *et al*., 2009; Corbera, 2010). The largest average biomass stocks for TOF were observed in Cameroon (16.4 Mg/ha) and in the Philippines (12.3 Mg/ha). The other countries had stocks of less than 10 Mg/ha and were in general in a comparable range to the stocks found on other wooded land (OWL). Average biomass stocks in forests were naturally higher and ranged from 21.8 Mg ha^{-1} to 159.9 Mg/ha. Kaul *et al.* (2011) has used remote-sensing based estimates of tree cover and growing stock outside forests in India, the estimated 2.68 billion trees outside forests contribute to an additional national average tree carbon density of 4 Mg/Cha in non-forest area, in comparison to an average density of 43 Mg/Cha. in forests.

Forests typically contain the major part of the tree biomass in the countries studied. However, for six out of the eleven countries more than 10 % of the total tree biomass was found outside forests and other wooded land, and in Bangladesh as much as 75 % of the national tree biomass stocks were estimated to be TOF, mainly because other land (OL) is by far the largest land-use classes.The total above-ground air-dried biomass of trees (≥10 cm DBH) in the Forest of Nepal is 1,159.65 million tonnes (Average: 194.51 t/ha). Out of the total above-ground tree biomass in forest, stem, branch and foliage share 60.74%, 32.36% and 6.90%, respectively. The total carbon stock in Nepal's Forest has been estimated as 1,054.97 million tonnes (176.95 t/ha). Out of this total, tree component (live, dead standing, dead wood and below-ground biomass), forest soils, and litter and debris constitute 61.53%, 37.80%, and 0.67%, respectively. It can be seen below in table 1.

Table 1: Carbon stock in Different Physiographic Regions

Physiographic Region	Carbon by Components (t/ha)		
	Tree component	Soil Organic carbon	Litter and Debris
Terai	104.47	33.66	0.28
Churia	97.69	31.44	0.32
Middle Mountains	79.42	54.33	1.65
High Mountains and High Himal	152.36	114.03	1.44
National average	108.88	66.88	1.18

Source: DFRS/FRA Main Report, 2015

Tree Biodiversity status in Trees Outside Forests

The role of trees that were grown outside of forests began to receive increased attention after the mid-1970s. Tree planting initiatives were identified as a potential strategy to meet the needs of growing populations, and at the same time address land-management problems and ecological concerns (Foley and Barnard, 1984; Nair, 1993; Tamale *et al*. ,1995; Arnold,1997; Long and Nair, 1999). Plantation of trees outside forest has been playing positive roles in carbon enhancement and biodiversity conservation in Nepal (Leah *et al*., 2010). Trees excluded from the definition of forest and other wooded land, include a great number of formations and species growing in rural and urban landscapes, including trees grown on farms, orchards, grazing land, unproductive lands, along roads and in cities (FAO, 2001; Bellefontaine *et al*., 2002). Trees that are planted outside of forests and trees in forests share many characteristics (Arnold, 1997; McCullough 1999); however, they are not entirely similar. In fact, Trees outside Forests (TOF) contribute to economic, environmental and social well-being in areas where there have never been forests or where forests have disappeared (Unasylva, 2000; FAO, 2001; Bellefontaine *et al*., 2002).

Tree planting initiatives were identified as a potential strategy to meet the needs of growing populations, and at the same time address land-management problems and ecological concerns (Foley and Barnard 1984; Nair, 1993; Tamale *et al.,* 1995; Arnold, 1997; Long and Nair, 1999). The agroforestry systems maintain species diversity and these systems can play an important role in biodiversity conservation in human-dominated landscapes especially in the urban areas (Bhagwat *et al*., 2008).Approximately 8000 tree species, or 9% of the total number of tree species worldwide, are currently under threat of extinction because of forest decline (Singh *et al*., 2005) and impacts of climate change. Deforestation continues at alarming rate which is consequently affecting on biodiversity in the tropics (FAO, 2010). The climate change, deforestation and forest degradation and biodiversity are interlinked with each other. Nepal occupies 0.09% of land area in the world (Colwell, 2005), which has 2.3% of global biodiversity. Nepal harbors around 3% and 1% of the world's floral and faunal species (GoN/MFSC, 2002). Total land surface area of Nepal is only 0.1% of the world's area but Nepal harbors 136 ecosystems, about 2 % of the flowering plants, 3% of the pteridophytes, and 6% of bryophytes of the world's flora. Out of that, 8 species are suspected to be extinct, 1 species is endangered, 7 species are vulnerable and 31 species fall under the IUCN rare species category (MFSC, 2000). In addition, important co-benefits, such as erosion control (Manning *et al.*, 2009; Baudry *et al.*, 2000) and the conservation and improvement of biological diversity (Paletto and Chincarini, 2012; Bhagwat *et al.*, 2008) can be obtained. TOF are also used as a source for food (Herzog, 1998), fodder (Hinsley and Bellamy, 2000), and wood products (Ahmed, 2008; Pandey, 2008). REDD+ mechanism has primarily focus on the carbon enhancement but biodiversity is considered as a co-benefit. Most of the countries in Asia like India, Pakistan, Bangladesh and Sri Lanka, Nepal are rich in biodiversity and obviously storing large amount of carbon stock. Terai region of Nepal is well-known for a tree outside of forest and hortosilviculture system orchard. Similarly this is high potential for storing the valuable vegetation carbon and plant biodiversity (Kharal and Oli, 2008; Mandal *et al.*, 2014). Nepal has been working with forest carbon partnership facility with the support of World Bank (MoFSC, 2010). Forest and TOF are considered as two faces of a coin in relation to their capacity for carbon stock and biodiversity (Kleinn, 2000). Private forest has increased throughout the country. Currently (as of 2013), there are 2,458 registered private forests in the country with a total of 3,329,885 trees grown in 2,361 hectares of private land (NBSAP, 2014). It is widely believed that there has also been a substantial increase in trees in community lands and other fallow lands in recent years. These resources outside public forests have helped alleviate pressure from national forests and made significant positive contributions to conservation of biodiversity (NBSAP, 2014). A study conducted by DFRS/FRA shows that the number of tree species identified in the Middle Mountains, Churia, High Mountains along with High Himal and Terai regions were 326, 281, 275 and 164, respectively which can be seen below in figure 2.

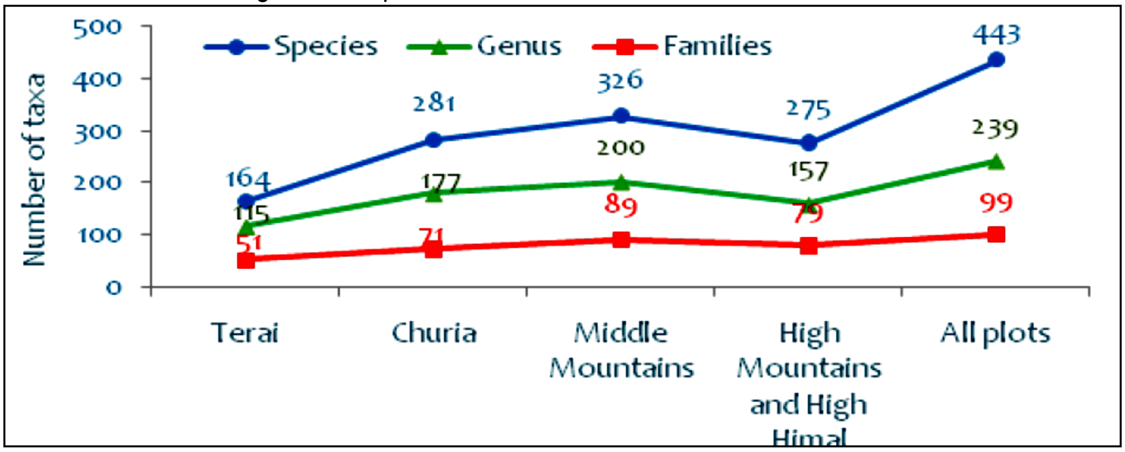

Figure 2. Number of Families, Genera and Species of Tree by Physiographic region
Source: DFRS/FRA Main Report, 2015

Importance of Tree Outside Forests in livelihood

The social diversity combines and interacts with factors such as social organizations, religious belief and access to land and markets to give rise to a wide variety of farming systems and great variances within them (Mahat, 1987; Gibbon and Schultz, 1989; Thapa, 1994) which in turn has resulted in several agroforestry practices. Gilmour and Nurse (1991) mentioned that farmers planted fodder trees on the nearest farmland in Nepal. Likewise, a large number of multipurpose trees and shrubs are deliberately retained or incorporated on farms in the subsistence farming systems on the steep slopes in different parts of Nepal (Fonzen and Oberholzer, 1985). The farmers who cultivate land for crops production also raise livestock, and depend upon tree resources for the support of both components (Mahat, 1987; Thapa, 1994). Tree growing practices in and around homesteads, and on farmland has long been associated in rural areas of Nepal, and hence, considered as integral components of rural livelihoods (Oli, 2002). These tree resources are considered as trees outside forest (GFRA, 2000). Regmi and Garforth, (2010) stated that the contribution of these trees and shrubs has high potential for livelihood improvement in the Nepalese context. A study carried out by Kharal *et al*. (2008) found that the trees outside forest contain 3.3 m^3/ha stem volumes in Nawalparasi district of Nepal. Farm tree and farm orchard are major the means of livelihood for local people (Sayer *et al*., 2013). On the other hand, socio-economic condition of the area affects farmland tree diversity (Kharal and Oli, 2008). Hence, there is a growing interest in assessing carbon sequestration potential and biodiversity of trees and shrubs on farms and its impact on rural livelihoods. Likewise, Prasad *et al.*, (2000) have studied in India that TOF plays a vital role in the livelihoods improvement of local people.

Although, the Nepalese tree resources outside forest can play a valuable role for enhancing sustainable development and people's livelihoods (FAO, 2002; Giri, 2004), the main focus has always been more on trees in forests that are viewed as a resource and a store of biological diversity. In addition, trees outside forests have not been included in national forest inventory, even though they have diverse functions for wellbeing of human-kind and in maintaining the natural environment (Oli, 2002). Therefore, this study attempts to assess the TOF with rural livelihoods and climate change mitigation through carbon sequestration. Although the contribution of tree outside forest has been appreciated, little is known about the resources itself (FAO, 2006). In India, TOFs are an important source of wood, other products, environmental services and livelihood. Furthermore, about 80% of the requirements of the wood-based industries are met from TOFs (Chave *et al*., 2004). Depending on prevalent land-use patterns and ecological and economic landscape attributes, TOFs also play a role in carbon sequestration, biodiversity conservation, pollution control, erosion control and enhance their livelihood. Corbera *et al*. (2010) have studied that the establishment of monitoring reporting and verification and reference emission level and assessing the strategy of social and environmental impacts assessment need robust and intensive data of forest carbon and biodiversity.

CONCLUSION

It has been seen that the carbon stock and biodiversity were varied in TOF. Generally in Nepal, the carbon stock is lower in TOF than the forest areas. Similar condition was recorded about the biodiversity because they are rich in forest area. Moreover, there multidisciplinary use of TOF at local level is highly significant. The TOF is especially utilizing for several purposes particularly for firewood, fodder, timber, non-timber forest products. Thus, different in depth researches regarding these scopes like carbon assessment, biodiversity status and contribution of TOF in livelihood promotion at different levels are required in the coming days.

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