

AGROFORESTRY SYSTEMS AND PRACTICES IN TERAI AND MID-HILLS OF NEPAL



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Executive Summary

Agroforestry is an age-old practice of growing forest crops and shrubs in and around agriculture field. Cultivating tree species, agricultural crops and pastures and/or animals in the same piece of land is ancient and still widespread in Nepal. These systems, combine tree species and shrubs with farm crops and livestock with interactive benefits. The agroforestry practice varies with physiographic region and within the physiographic region varies with locations. The study conducted to explore and document the agroforestry practices prevailing in *terai* and mid-hills of Nepal. One hundred and forty agroforestry farms in forty-four districts of predefined transects were surveyed; in addition Division Forest Offices, Agriculture Knowledge Centers and related stakeholders were consulted.

The study showed that agroforestry practices were different and mostly traditional agroforestry practices were adopted in *terai* and mid-hills, however the species composition varies. Agroforestry practices in *terai* were tree-based commercial agroforestry practices, focused on timber species such as eucalyptus, tectona, poplar. Similarly, agroforestry practices in the central parts of mid-hills were farm-based subsistence practices dominated by fruits and fodder trees whereas, farm-based commercial practices were widely adopted in western and eastern mid-hills dominated by tea, coffee, cardamom, and some other minor forest products. Coffee, tea, cardamom, orange were the primary product whereas, fodder and fruit trees were secondary products. The agroforestry practices were adopted mostly by well-off households (i.e. having more farmlands) in *terai* and midhills.

Limited technical know-how among the farmers, farm labor shortage, limited market linkages, fragmentation of land and increasing number of dry days are the considerable challenges in the agroforestry practices in both regions. Increasing abandoned areas and degraded forest areas in the region have widened the scope of agroforestry. Agroforestry practices and species composition needs to improve for sustainable productivity and adoptability along with improvement in environmental condition of the region.

Keywords: Agroforestry, practices, integration, crops, *terai*, mid-hills and farmers.

CHAPTER: ONE

INTRODUCTION

1.1 Background of the country

Nepal is located in the central part of the Himalayas in between 26°02' and 30°27' N latitudes and 80°04' and 88°22'E longitudes and covers an area of 1,47,181 square kilometres with wide ranges of geographic condition (CBS, 2001). The altitude ranges from 60m in the south to 8848m in the north from the sea level (Hagen, 1998). The climate varies from subtropical to alpine from lowland to high himal respectively. The country has different ecological belts endowed with different types of climates due to its unique geographical position.

Nepal is divided into five physiographic zones based on altitude extending from south to north, namely high himal, High Mountain, Middle mountain, Siwalik and *Terai*. The High himal lies climates above 5000m in the northernmost part of the country with a very cold and dry climate. It covers 23% of the total land area of the country. The High Mountain lies at an elevation of 4000m to 5000m characterized by high, steep slopes and deep gorges with sub-alpine and alpine. It covers 19% of the total land area of the country. Middle mountain ranges from 1000m to 3000m elevation from sea level and covers 29% of the country's land area. It has subtropical to temperate monsoonal climate and characterized by a great variety of terrain types. It has a rich diversity of ecosystems and species and considered Physio-graphically the most diverse region. Siwalik is a mountain range, locally known as the Mahabharata, separates the Siwalik Hills from the Middle mountains. The Siwalik is typically ranging in elevation from 500m to 1000m and covers 15% areas of the country. The Siwalik hill exhibits a very immature topography with highly rugged terrain. The *terai* comprises of a narrow belt of flat and fertile land in the southernmost part of the country below 500 meters from the sea level. The natural vegetation consists of scattered patches of tropical evergreen and deciduous forests, and riverine forests (GoN/MoFSc, 2014).

Based on climate the country is divided into pre-monsoon, monsoon, post-monsoon, and winter seasons. The climate is predominantly influenced by altitudinal variations, monsoon, and

westerly disturbances (WECS, 2011). Temperature varies with topographic variations in the country. The temperature of the lowland is higher than in high land. The winter temperature is between 22°-27°C while the summer temperature exceeds 37°C in the *terai* whereas, in the mid-hills, the temperature is between 12° – 16° C and in higher up occasionally (Amatya, Cedamon and Nuberg, 2018)

1.2 Agroforestry and its development

Agroforestry is a land use system in which agricultural crops and/or animals are integrated simultaneously or sequentially to get higher productivity, more economic returns and better social and ecological benefits on a sustained yield basis on the same unit of land, especially under conditions of low levels of technological inputs and on marginal sites (ICRAF,1982). In agroforestry woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In other words, the combination of agroforestry components, especially species having unique biological and economical relationships, possessing similar management strategies and techniques is known as the agroforestry practice (Lundgren and Raintree, 1983).It optimizes the utilization value of land with integrated components contributing to food security and the livelihood of rural people. Farmers have been practicing agroforestry with locally suitable species since time immemorial with indigenous knowledge, especially as subsistence farming. However, they are also practicing agroforestry with exotic species and gradually inclined towards commercial agroforestry practices. Agroforestry practices vary according to topographical variation, i.e. altitude and aspects.

The historical record shows that nomadic herders have practiced transhumance system mainly in the Dzongkhags of Haa, Thimpu, Paro, Gasa, Wangdi Phodrang, Bumthang and Trashigang of Bhutan in which they keep yaks and sheep as their only source of livelihood (Amatya, Cedamon and Nuberg, 2018). In the Bangladesh, people commonly plant trees on homestead and along the vicinity of farmland boundaries. In the Maldives, trees and shrub species *Gliricidia*, *Sesbania*, *Erythrina* are used in agroforestry as fodder for livestock and to serve as wind breaks. In Srilanka, two types of home garden systems are practiced; traditional and modern. Jackfruit

(*Artocarpus Integra*) constitutes as an important component of Sri-Lankan home garden for household consumption as a traditional system while modern home gardens are cash generating agroforestry system through planting tree species that yield spices, beverages and sap. Comparatively, agroforestry in India is more developed than those of other South Asian countries. Both farm and forestry-based agroforestry systems are practiced. The intensity and use differ along with the agro-ecological zones of the country. Within village grazing grounds, Silvopastoral practices are being practiced where villagers have their tenure rights. This system in forest involves lopping trees and grazing under-story ground grasses (Amatya, Cedamon and Nuberg, 2018). Taungya system was introduced to South Africa as early as 1887 (Hailey, 1957) and was taken from Burma to Chittagong area in India in 1890 and to Bengal in 1986 (Raghavan, 1960).

In Nepal, Taungya system of agroforestry was first practiced at Tamaghadi, Bara district by Forest Department in coordination with Sagarnath Forestry Development Project in early 1974-75 to protect the *Shorea robusta* and its associate trees *Terminalia alata*, *Adina cordifolia* and *Anogonites latifolia*. Maize, mustard, tobacco and other seasonal vegetables were planted in between the trees of *Eucalyptus camaldulensis*, *Dalbergia sissoo* and *Tectona grandis* and harvested the agricultural crops twice a year. The essence of this system is involving landless poor local villagers as Taungya planters and minimize the weeding cost. Due to the resistance of farmers to settle in the areas permanently rather than practicing intercropping and government also could not provide new areas to Taungya settlers, this practice no longer exists in the country, despite all the positive biophysical aspects of tree growth (Amatya, S., Eedamon, E., Nuberg, I. 2018).

The major agroforestry practices in Nepal include home gardens, agri-silviculture, silvi-pastoral system, agro-Silvo-pastoral system, alley cropping, horti-silviculture system and aqua-silviculture. Shifting cultivation is still practiced in many upland areas of the country, though it is declining (Amatya, S., Eedamon, E., Nuberg, I. 2018).

Despite the huge potentiality of benefits from the Agroforestry system farmers are not getting optimum benefits. Agroforestry is mostly limited to small household's subsistence farming. However, some farmers are gradually attracted to commercial agroforestry systems nowadays.

On the other hand, there is an information gap between researchers and farmers on potential agroforestry practices in different regions of Nepal. Traditional agroforestry practices in Nepal are documented to some extent. However, the commercial or large-scale agroforestry practices have not documented yet. Similarly, the suitable agroforestry species and species combination for specific regions are not documented. Due to this, farmers are facing challenges of getting actual benefits of agroforestry. Amatya (1999) documented the characteristics of Nepalese agroforestry practices across 22 districts representing four physiographic zones i.e. *Terai*, Mid-hills, High-hills, and High Mountains.

1.3 Agro-ecological zones and agricultural practices

Nepal has different agro-ecological zones with a variety of climates ranging from tropical in the *terai* to alpine in the high mountains. Nepal has three major agro-ecological zones, namely the *terai* region in the south, the hills in the nation's mid-section, and the mountainous region in the north (<http://ibn.gov.np/agriculture>). Depending upon the agro-ecology and their household needs and priorities, farmers grow different crops and raise different livestock complementary to each other. About 66% of people in Nepal are directly engaged in agriculture. They are practicing mostly subsistence-based farming in which the crops are mostly integrated with livestock. Farmers cultivate rice, maize, millet, wheat, barley, and buckwheat as the major food crops. Similarly, the important cash crops are oil seeds, potato, tobacco, sugarcane, jute, and cotton, whereas lentil, gram pigeon pea, blackgram, horsegram and soybeans are the major pulse crops. Nepal is also recognized for cash crops such as orthodox tea, large cardamom, turmeric, and zinger. Apple, peach, pear, plum, walnut, orange, lime, lemon, mango, litchi, banana, pineapple, orchid, cucumber, lady's finger, brinjal, pumpkin and several leafy vegetables are the fruits and vegetables grown in various agro-ecological regions. Livestock products are one of the important income sources of the farmer. Buffalo, cow and, the goat are the major livestock rearing in *terai* whereas cow, goat, sheep and rural poultry are in the hills. In the

mountains, yak and sheep are the major livestock raised. Poultry husbandry and freshwater fishery in *terai* and rainbow trout in the hills, and in the lower mountains are the emerging enterprises (Sharma, <http://www.fao.org/3/x6906e/x6906e09.htm>).

1.4 Agroforestry research and policy in Nepal

The research in the context of agroforestry dynamics is not new in Nepal. Agroforestry systems generally involve agricultural crops, tree crops, and livestock in Nepal (Amatya, 1996), but have evolved from simple agriculture into a range of farming systems with varying degrees of integration (less integrated, semi-integrated, and highly integrated agroforestry) including specific agroforestry practices such as home gardens, silvopastoral and forest-based systems (Amatya and Newman, 1993; Dhakal et al., 2012). The economic and environmental benefits of agroforestry have been widely reported by many authors, and more recently, its contribution to climate change mitigation and adaptation has been acknowledged (Paudel et al. 2014a). Dhakal et al. (2012) pointed that the design and level of integration of plant components in Nepalese's agroforestry as a reflection of farmers' knowledge of the benefits of agroforestry, both economically and ecologically. Besides the consideration of the benefits, some studies also reported that the farmers' decision in tree-crop selection for their agroforestry farmlands was also influenced by biophysical factors such as topography and soil fertility that determine land suitability and access to markets, and socioeconomic factors such as the household economy and cultural traditions.

Agroforestry has been increasingly receiving the attention of researchers, policy-makers, farmers and others due to its potentiality to contribute significantly to poverty reduction, economic growth, environmental quality and national prosperity. With increasing attention of the entire stakeholders towards agroforestry helped to formulate the National Agroforestry Policy (NAP) 2076. The NAP has emphasized on easing of regulatory constraints and facilitates the development of agroforestry practices, income generation, food, nutritional and energy security, controlling land degradation and development of various agroforestry models for different agro-ecological zones. The policy has a provision of Agroforestry Inter Ministerial Coordination Committee (AFIMC) for its implementation at the central level. Ministry of agriculture and livestock development is the nodal ministry for implementation of the policy and initiatives.

CHAPTER: TWO

MATERIALS AND METHODS

2.1 Objectives

The objectives of the study were to explore and document the existing agroforestry systems/practices in *terai* and mid-hills of Nepal.

2.2 Study Area

The study were carried out in two physiographic region of Nepal namely; *terai* and mid-hills region of Nepal. The *terai* region occupies 2,016,998 hectare and is located in a sub-tropical climatic zone of the country. The climate is characterized by hot and humid summers, intense monsoon rain, and dry winters. The maximum monthly mean temperature, 35- 40°C falls in April-May and the minimum, 14-16 °C, in January. Population growth rate of 1.75%, the highest in the nation, have resulted in heavy pressure on the forest resources. The *terai* region have exemplary practice of agroforestry practices in Nepal. Similarly, the middle hills or middle-mountains region occupies 29.2% of the total land area of the country. The elevation varies from 110 m to 3,300 m and climate ranges from sub-tropical, sub-humid in river valleys to warm-temperate in valleys and cool-temperate in the high hills ((GoN/MoFSc, 2014).

One hundred and forty private farmlands and leasehold forests covering seven provinces and forty-four districts were visited and observed. The districts comprises of nineteen *terai* and twenty-five mid-hills. The forty-four districts were grouped into eight transects (Table 1).

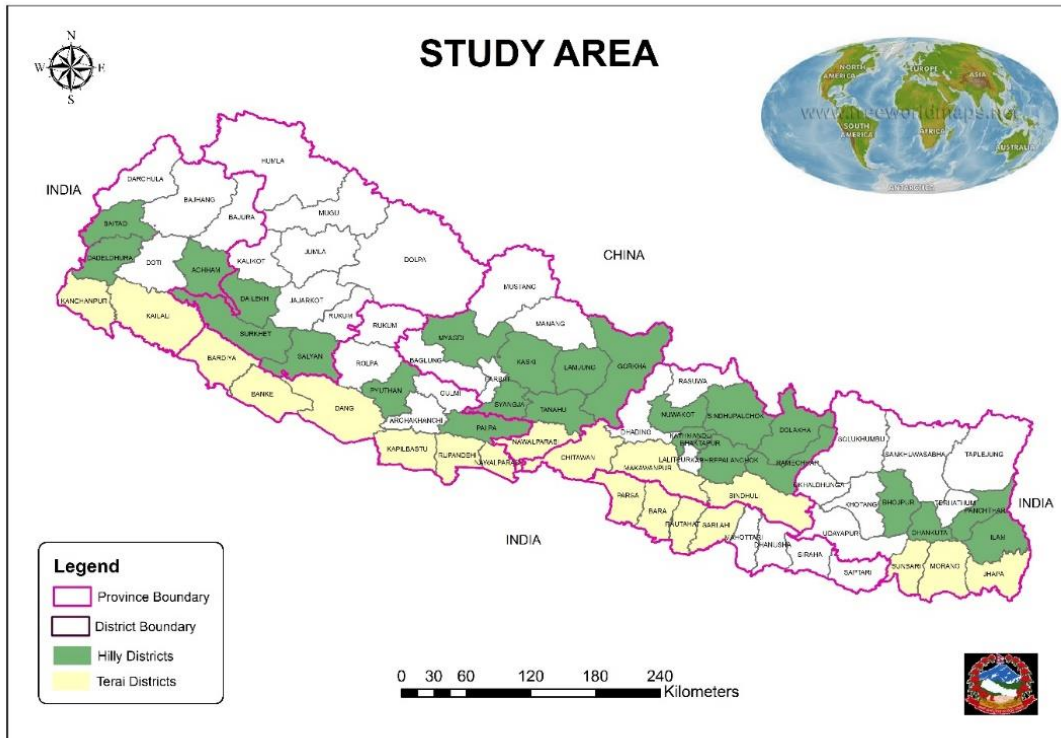


Figure 1 Study area

Table 1 Identified transects and districts

Transects	Districts
1	Makwanpur-Parsa-Bara-Rautahat-Sarlahi
2	Panchthar-Ilam-Jhapa-Morang-Sunsari-Dhankuta-Bhojpur
3	Kavre-Sindhupalchok-Dolakha-Ramechhap-Sindhuli
4	Kathmandu-Bhaktapur- Nuwakot
5	Chitwan-Nawalparasi-Kapilbastu-Rupandehi-Palpa-Dang-Pyuthan
6	Tanahu-Gorkha-Lamjung-Kaski-Syanja-Myagdi
7	Banke-Bardiya-Surkhet-Dailekh-Salyan
8	Kailali-Kanchanpur-Dadeldhura-Baitadi- Accham

2.3 Methodology

The study was qualitative to explore existing agroforestry systems, practices, knowledge, opportunities, challenges, and possibilities in *terai* and mid-hills of the country.

A qualitative data collection method was used, which includes desk review, semi-structured interviews, focus group discussions, phone interviews, photographs and video capture, consultation with Division Forest Offices, Agriculture Knowledge Centres. Eight transects were laid covering forty four districts of seven provinces and two physiographic region namely *terai* and mid-hills where commercial and traditional agroforestry practices have been adopted (Table 1)

The agroforestry farms along transects were selected based on pre-set criteria. Altogether one hundred and forty agroforestry farms were visited and observed. The fieldwork was conducted from November 2018 to May 2019 for about 200 days.

2.4 Limitation of the Study

The study was conducted to explore the existing agroforestry systems and practices along with video documentation in *terai* and mid-hills; however, the study was conducted only in one hundred and forty representative agroforestry farms of forty-four districts .Therefore, this study may not explore entire agroforestry practices in the country.

CHAPTER: THREE

RESULTS AND DISCUSSIONS

Agroforestry Systems

Altogether 12 agroforestry systems and 41 agroforestry practices were identified in forty four districts of *terai* and mid-hills physiographic region. 10 agroforestry systems and 19 agroforestry practices in *terai* and 7 agroforestry systems and 22 agroforestry practices were identified in mid-hills region of Nepal. Similarly, 7 agroforestry systems and 35 agroforestry practices in eastern, central and far-western region of Nepal were identified by Amatya *et. al.* 2018. Major Agroforestry systems identified are:

1. Agrisilviculture system

In this system, trees and crops are grown together in the same piece of land in various temporal and spatial arrangements. This agroforestry system has been adopted both in *terai* and mid-hills of the country. However, the woody perennial species and cash crops varied in *terai* and mid-hills as well as the eastern and western parts of the country. Generally, fast-growing exotic tree species such as *Eucalyptus*, *Tectona* were preferred in *terai*, whereas in the hills both indigenous and exotic tree species were preferred, and it also varied with the objectives of the farm. The major tree species in *terai* were *Eucalyptus camaldulensis*, *Tectona grandis*, *Dalbergia sissoo*, *Melia azedarach*, *Populus* species, and *Albizia* species, while in the mid-hills *Alnus nepalensis*, *Prunus cerasoides*, *Paulownia* species, *Elaeocarpus* species, and *Michelia Champaca*. In agri-silviculture systems, four different practices such *Camelia sinensis* (Tea) under *Albizia procera* and *Dalbergia sissoo*; Turmeric and ginger under *Eucalyptus camaldulensis*; Seasonal agricultural crops under *Tectona grandis*, Seasonal agricultural crops along with mixed tree were adopted in *terai* whereas, 10 different practices such as tea under *Alnus* species, *cardamom* under *Alnus* species were adopted in the midhills.

2. Agrosilvipastoral system

Trees, crops, pasture, and/or livestock are raised in the same piece of land simultaneously and sequentially. This system has been practiced at the livelihood level and promotes agriculture and animal husbandry in *terai* and mid-hills. However, some farmers have begun to adopt at commercial level. Various grass species such as Napier, Stylo, Broom grass, C4, and seasonal crops planted under the fodder tree, as well as goat and cow rearing, were practiced in the same piece of land. Goat farming and timber production were major objectives in the *terai*, whereas grass production, goat farming, and cow rearing in the mid-hills. In *terai* and mid-hills 2 agroforestry practices were adopted.

3. Silvopastoral system

A System in which grasses and fodder trees are grown together with timber tree species are called silvopastoral system. This system was mostly practiced in the central part of the mid-hills, i.e. Gorkha, Kavre, and Kaski district. The fodder tree species such as *Ficus semicordata*, *Litsea monopetala*, *Artocarpus lakoocha*, *Leucaena leucocephala*, *Melia azadarach*, and *Ficus lacor* planted along with various grass species, such as Napier, Molasses, C4, etc. along terrace bund, border, and slopes. Besides, fodder trees and grasses, some other tree species such as *Schima wallichii*, *Santalum album*, *Ziziphus budhensis*, and *Albizia* species were also planted in a random pattern. Goat and cow rearing were mostly practiced along with tree and grass species.

4. Home garden

The Home garden has been practiced in *terai* and mid-hills of Nepal, however, the tree species vary in the *terai* and mid-hills as well as the eastern and western region. In the home garden, intensive cultivation of the annual, perennial crops, grasses cultivated and animals reared intensively in multilayer strata were observed. *Artocarpus lakoocha*, *Schima wallichii*, *Castonopsis indica*, *Ficus semicordata*, *Ficus glaberrima*, and *Persea odoratissima* were the major tree species in the mid-hills, whereas *Dalbergia sissoo*, *Anthocephalus chinensis*, *Leucaena leucocephala*, *Artocarpus lakoocha*, *Melia azederach* in the *terai* agroforestry farms. The seasonal crops and vegetables crops were mostly similar in *terai* and mid-hills.

5. Hortiagriculture system

Hortiagriculture system consists of the main crop, filler crop and intercrops with different layer and production system, but in some cases the filler is absent (Dalvi *et al.*, 2019). Crops such as lentil, chilly, and seasonal vegetables were grown under the fruit trees. This agroforestry system adopted both in the *terai* and mid-hills, however, the species were varied. The major fruit trees planted in *terai* were *Magnifera indica*, *Litchi sinensis*, *Psidium guajava* and *Citrus limon*. Whereas, in the hills, planted *Citrus sinensis*, *Musa sapientum*, *Citrus sinensis*, *Choerospondias axillaris* and *Prunus communis*. The crops were generally seasonal vegetables, potato, ginger and turmeric in *terai* and mid-hills. In *terai* 1 agroforestry practice and in mid-hills 5 agroforestry practices were observed.

6. Agrisilvihorticulture system

Agroforestry that combine agriculture crops, forest and fruit trees together in the same piece of land at the same time. This system has been adopted in *terai* and mid-hills with various different species combination with respect to location. In *terai* region, *Dalbergia sissoo*, *Eucalyptus camaldulensis*, *Shorea borneensis*, *Tectona grandis* were intercropped with mango, litchi, jackfruit and ginger, turmeric, yam, colocasia and seasonal vegetables were cultivated underneath. However, the pattern of planting agriculture crops, fruit trees, and forest tree species were varied with location. Similarly, in mid-hills cardamom were cultivated along with rudrakshya, cinnamon and banana in different pattern and strata. In *terai*, 4 agroforestry practices and in mid-hills, 1 agroforestry practices were observed.

7. Hortisilviculture system

Trees and fruit trees are grown together in different strata and pattern in the same piece of lands at the same time. This system has been mostly adopted in *terai*, where *Eucalyptus camaldulensis*, *Tectona grandis*, *Luceana leucocephala* were grown with mango, litchi, banana, avocado, jackfruit in various pattern and strata. This system was more common in the western *terai* region, where tree species were grown around the bunds of the field as well as intercropped with mango. However, this practice is rarely observed in the eastern and central *terai* region. In *terai* 3 agroforestry practice and in mid-hills no such agroforestry practices were observed.

8. Silvofishery or aquasilviculture

This system consists of growing of trees around the fish pond. In this system, trees and fruit trees are planted along the embankment of the fish pond. This system is popular in *terai* and inner-*terai* of Nepal, where trees and fish were included in the same system. Sissoo, eucalyptus, teak, banana and mango were planted along the dyke of fish ponds. Some farmers also included duck and pigs in aqua-silviculture systems. In *terai*, 2 agroforestry practices and in mid-hills no such agroforestry practices were observed.

9. Agrosilvifishery

In this agroforestry system, trees and agricultural crops are planted around the fish pond. Eucalyptus, teak, various lentil species, pea and pinto bean were planted along the embankment of the fish pond. This system was widely adopted in *terai* and inner-*terai* of Nepal.

10. Apiculture

This agroforestry system is the combination of trees and bees. This agroforestry practice was adopted both in *terai* and inner *terai*. Melifera bee species were introduced with plantation of teak, paulownia in the marginal land. Vegetable crops were often introduced in this system.

11. Agrohertosilvopastoral

Agriculture crops, fruit trees and timber species are grown together in different strata and pattern and livestock are introduced in *terai*, where *Eucalyptus camaldulentsis*, *Tectona grandis*, *Luceana lucocephala*, *Elaeocarpus sphaericus*, *Shorea borneensis*, *Acacia catechu*, and livestock were grown with mango, litchi, banana, avocado, jackfruit in various pattern and strata.

12. Hortosilvipastoral

Agriculture crops, fruit trees and timber species are grown together in different strata and pattern and livestock are introduced ; *Swertia chiraita*, *Zanthoxylum armatum*, fodder trees, fruit trees and multipurpose trees and grasses along with livestock in various pattern and strata.

Agroforestry systems and practices in *terai* region of Nepal

The practice of integrating and managing agricultural crops and livestock along with forestry components with dual objective of food security and subsistence livelihoods is a common practice in *terai* region of Nepal. The agroforestry practices in *terai* are complex integration of trees with understory crops, performing several production and protection services. Agroforestry systems and practices recorded in the *terai* region are:

1. Agrisilviculture System

1.1 *Camelia sinensis* under *Albizia procera* and *Dalbergia sissoo*

Camelia sinensis is one of the most commercial crop planted in eastern region. The combination of *Camelia sinensis* and tree species were common agroforestry practice in the Jhapa district. *Camellia sinensis* were grown along with the *Albizia procera* and *Dalbergia sissoo* in a random mixed pattern. Generally, tree species serves as a windbreak and shelterbelt, farmer hardly harvest these tree species.



Figure 2: *Camelia sinensis* under *Albizia procera* and *Dalbergia sissoo*

1.2 Turmeric and ginger under *Eucalyptus camaldulensis*

Eucalyptus camaldulensis was the primary species, planted in about 2*3m spacing intercropped with turmeric and ginger. In the first and second-year of plantation, seasonal agricultural crops such as cauliflower, tomato, chilly, and mustard were planted for additional income. However, the productivity of vegetables decreased with increasing shade. Generally, farmers do not prefer to plant other agricultural crops except turmeric and ginger under eucalyptus as

they experienced very low productivity. The practice was adopted from eastern to the mid-western *terai* region of Nepal basically, Bardia, Banke, Kailali, Kanchanpur, Dang, Kapilvastu and Dhanusha districts. Farmers expressed that benefit is higher than in traditional agricultural practices. Nowadays, farmers are more inclined towards the plantation of Eucalyptus because of its low labor-intensive nature, low risk of disease and pest, low time consumption and good marketability nature. However, they believed those Eucalyptus plantations have reduced the water table of the area.



Figure 3 Turmeric and ginger under *Eucalyptus camaldulensis*

1.3 Seasonal agricultural crops under *Tactona grandis*

Tectona grandis were intercropped with mustard, red lentils, beans, turmeric, and other vegetables. The practice was most common in central and western *terai* region. Inter-cropping of mustard and red lentil with teak was common in Banke and Bardiya. In the eastern region teak were planted in hedgerow along with seasonal crops. The Farmer believed that the teak along with eucalyptus suppress the agriculture products, as eucalyptus lower down the water table and increase the acidity of the soil and preferred plantation of teak. The market price of teak is high and farmers expected four or five times more income than traditional agricultural practices. The farmers in the western *terai* were inclined towards the plantation of teak because of its low labor-intensive, low risk of disease and pest, low time consumption and good marketability of the products.



Figure 4: Seasonal agricultural crops under *Tactona grandis*

1.4 Seasonal agricultural crops along with mixed tree species

Tectona grandis, *Eucalyptus camaldulensis*, *Melia azedarach*, *Litsea monopetala*, and Bamboo were grown in the bund and border of the field as hedgerows and seasonal cereal crops paddy, maize, mustard were planted in the field. This was a specific case with some similar features with the leasehold forest. This practice was found in Hardauna of Kapilvastu district.

2. Hortisilviculture System

2.1 *Eucalyptus camaldulensis* and *Mangifera indica* along with asparagus, citronella, palmarosa and mentha

Citronella, asparagus, palmarosa and mentha were grown together with Eucalyptus and mango trees in random mixed pattern. These species occupied lower stratum whereas mango and eucalyptus cover middle and upper stratum respectively. This agroforestry practice was observed in Sarlahi district of eastern *terai* region, however, farmers in eastern region now gradually shifting towards monoculture of *Eucalyptus camaldulensis*.



Figure 5 : *Eucalyptus camaldulensis* and *Mangifera indica* along with asparagus, citronella, palmarosa and mentha

2.2 Banana along with *Eucalyptus camaldulensis* and *Tectona grandis*

In this practice, bananas formed a key component, but many other tree species were also present. Major tree species were *Eucalyptus camaldulensis* and *Tectona grandis* arranged in two different patterns 1) Banana inter-cropping with eucalyptus or teak 2) Banana and tree species in two different patches but within the same piece of land management system. Although, planting of eucalyptus with other species (mixed species trials) has been shown to hasten the decomposition of the litter and enrichment of the soil, the majority of farmers have criticisms of eucalyptus having allelopathic effect on other plants. They were worried about eucalyptus foliage and root exudates that hinder the growth of the banana so that they have chosen parallel cropping system in different patches in same piece of land. This practice was found more common in the western *terai* region, mainly Banke, Bardiya, Kailali and Kanchanpur districts. The practice of inter-cropping of banana with eucalyptus or teak was found in Kanchanpur. The farmer experienced the practice is three to four times more profitable than traditional farming practice.



Figure 6: Banana along with *Eucalyptus camaldulensis* and *Tectona grandis*

2.3 Mango along with *Eucalyptus camaldulensis* and *Tectona grandis*

Eucalyptus camaldulensis and *Tectona grandis* intercropped with mango. The trees were planted in the bunds or farm land. *Eucalyptus camaldulensis* and *Tectona grandis* were grown to reduce wind velocity and to provide shelter to mango trees. This agroforestry practice were adopted from eastern to western *terai* region however, management practice varied. Farmers expected three-four times more profit with this combination than traditional farming system.



Figure 7: Mango along with *Eucalyptus camaldulensis* and *Tectona grandis*

2.4 Avocado and pomegranate along with tree species

Avocado and pomegranate were planted along with *Eucalyptus camaldulensis*, *Tectona grandis* and *Melia azedarach*, however avocado and pomegranate were the focused species. Avocado and pomegranate were planted at the spacing of 4m*4m, and *Tectona grandis* were intercropped with them, whereas, *Eucalyptus camaldulensis* and *Melia azadirach* were planted on the periphery of the land. The growth performance of avocado and pomegranate were not satisfactory. Therefore, the farmer has planned to replace the avocado and pomegranate with mango and litchi. This practice was adopted in Nawalparasi in central *terai* region.



Figure 8 Avocado and pomegranate along with tree species

3. Hortiagriculture system

3.1 Fruit trees along with seasonal agriculture crops

The mango trees were planted at a wider spacing at more than 5m*5m providing enough space for intercrops. Other fruit trees were litchi, guava, banana, and lemon were planted

around the farm or in random mixed pattern. Seasonal cereal crops such as wheat, mustard, and vegetables such as tomato, onion, cauliflower, beans, radish and cash crops were intercropped with mango. The products from fruit trees were sold in the local market whereas the cereal crops and vegetable were used to fulfill the livelihood needs. This practice was adopted commonly in Banke, Bardiya, Surkhet and Kailali districts.



Figure 9 Fruit trees along with seasonal agriculture crops

4. Agrosilvihorticulture System

4.1 Agricultural crops along with banana and tree species

Tectona grandis, *Eucalyptus camaldulensis*, *Melia azedarach* and *Litsea monopetala* were grown in the bund and border of the field as a hedgerow whereas, banana were planted in random mixed pattern. Paddy, maize, mustard were cultivated seasonally in the field.



Figure 10 Agricultural crops along with banana and tree species

4.2 Fruit trees and agricultural crops along with *Tectona grandis* , *Shorea borneensis* and *Dalbergia sissoo*

Teak, betelnut, malaysian sal, rudraksha, and sissoo were planted along with papaya, mango, litchi, pomegranate and banana in random mixed pattern or around the field or in a different spatial pattern. Similarly, seasonal agricultural crops, vegetables and cash crops such as turmeric, ginger were also cultivated under the fruit trees until fruit trees do not cast shade. This agroforestry practice was adopted in Jhapa, Morang and Sunsari districts of the eastern *terai* region. The forest tree species and fruit trees were planted for commercial purpose, whereas agriculture crops for household use.



Figure 11 Fruit trees and agricultural crops along with *Tectona grandis*, *Shorea borneensis* and *Dalbergia sissoo*

4.3 Fruit trees, agricultural crops and seasonal vegetables along with eucalyptus

The agricultural crops and seasonal vegetables were intercropped with mango, litchi, jackfruit in random mixed pattern and the eucalyptus and banana trees were planted around the boarder. The agricultural crops and vegetable crops covered lower stratum and mango, litchi, jackfruit, eucalyptus covered the middle and upper stratum of the farm. This agroforestry practice was observed in Dhanusa district of eastern *terai* region. Eucalyptus and fruits were planted for commercial purpose, whereas the agricultural crops and vegetables for household consumption.



Figure 12 Fruit trees, agricultural crops and seasonal vegetables along with eucalyptus

4.4 Mango and agriculture crops along with *Eucalyptus camaldulensis*, *Tectona grandis*, *Populus species*, *Melia azedarach*

Eucalyptus camaldulensis, *Tectona grandis*, *Populus species*, *Melia azedarach* were planted around the boarder of the land whereas mango and seasonal agriculture crops intercropped in random mixed pattern in the field. In the early stage, wheat, mustard, lentil, ginger, turmeric and seasonal vegetables like cauliflower, potato, bean and onion were intercropped whereas, eucalyptus, tectona, populus, and melia were planted in the bunds as a hedgerow. The shade of mature mango trees limits the range of crops suitable for integration, so the productivity of agriculture crops declines with the growth of mango trees. In the later stage, consequently leads to hortisilviculture with mango and tree species. This agroforestry practice is about five times more profitable than the traditional agriculture system. Mango based Agrosilvihorticulture practice is popular and widely adopted in Banke, Bardiya and Surkhet district of western *terai* region.



Figure 13 Mango and agriculture crops along with *Eucalyptus camaldulensis*, *Tectona grandis*, *Populus species*, *Melia azedarach*.

5. Agrosilvipastoral system

5.1 Agricultural crops along with *Acacia catechu*, *Elaeocarpus ganitrus* and pig farming.

Acacia catechu, *Elaeocarpus ganitrus*, *Bombax ceiba*, *Tectona grandis* and *Ficus semicordata* were planted along with mango, litchi, lemon, pomegranate in random mixed pattern whereas, ginger, chilly, and garlic were cultivated under the trees. Pig farming were carried out in the flat land adjoining to field. This agroforestry practice was found in Sunsari district. The major component of farming practice was pig farming.

5.2. Agricultural crops, tree species along with grasses and livestock

The ideal combination of grasses, legumes and commercial fast-growing tree species were planted for producing highly nutritious top fodder, forage, fuel wood, and timber along with seasonal agricultural crops and livestock at the same piece of land. *Eucalyptus camaldulensis*, *Tectona grandis*, *Melia azedarach*, *Dalbergia Sissoo* and *Paulownia tomentosa* were planted along with highly nutritious grass species such as australian grass, mendola, C4 and forage peanut (badame) around the field. Maize, mustard, wheat, paddy, seasonal vegetables, turmeric, ginger, beans, etc. was also cultivated and at the same time goat, cow and hen were also raised. This agroforestry practice was adopted in Surkhet and Dang district on commercial scale. The Farmers believes the risk reduction and economic losses by diversification of farming activities.



Figure 14 Agricultural crops, tree species along with grasses and livestock

6. Agrohortosilvopastoral

6.1 Agricultural crops and *Areca catechu* along with *Tectona grandis*, *Eucalyptus camaldulensis*, *Elaeocarpus ganitrusa*, *Shorea borneensis*, *Acacia catechu* and livestock

Betelnut based agroforestry practice was observed in Jhapa and Morang districts of eastern *terai*. Betelnut was planted along with *Tectona grandis*, *Eucalyptus camaldulensis*, *Elaeocarpus ganitrusa*, *Shorea borneensis* and *Acacia catechu* around the border, whereas, fruit tree species such as jackfruit, mango, litchi, and lemon intercropping with seasonal crops at the random mixed pattern. Along with plant species, livestock (goat, cow, buffalo and poultry) was also raised in the adjoining field. However, the major focus was on betelnut. The seasonal crops were only cultivated in the early stage of tree species as crop productivity reduced by the shade of trees.



Figure 15 Agricultural crops and *Areca catechu* along with *Tectona grandis*, *Eucalyptus camaldulensis*, *Elaeocarpus ganitrusa*, *Shorea borneensis*, *Acacia catechu* and livestock.

7. Silvofishery or aqua-silviculture

7.1 Fish farming in conjunction with *Eucalyptus camaldulensis*, *Tectona grandis*, Mango and *Dalbergia sissoo* trees.

Fish farming along with *Eucalyptus camaldulensis*, *Tectona grandis*, *Dalbergia sissoo* and mango planted around the dyke of the pond. In Parsa district, this agroforestry practice was widely adopted. Fish farming was the major component of the farming system. The farmer experienced the production of fishes with eucalyptus trees on the border or dyke of the pond was quite less than other species on the border or dyke of the pond. Farmers believed that the leaves of eucalyptus make pond's water better.



Figure 16 Fish farming in conjunction with *Eucalyptus camaldulensis*, *Tectona grandis*, *Mango* and *Dalbergia sissoo* trees

7.2 Fish farming along *Tectona grandis*, *Paulownia tomentosa*, and *Shorea borneensis*

Tectona grandis, *Paulownia tomentosa*, *Shorea borneensis* and other indigenous tree species were planted along with fish farming. The tree species were planted along and around the dyke of the pond as well as in and around the adjoining farm. This silvo-fishery practice was adopted in Jhapa district of eastern *terai* region of Nepal. Though the major component of the farm was fishery, the *Tectona grandis*, *Paulownia tomentosa*, *Shorea borneensis* were also the commercial component of the farming.



Figure 17: Fish farming along *Tectona grandis*, *Paulownia tomentosa*, and *Shorea borneensis*

8. Apiculture

8.1 Bee farming in conjunction with *Tectona grandis* and *Paulownia tomentosa*

The *Mellifera* bee farming along with *Tectona grandis*, *Melia azadirach*, and *Paulownia tomentosa*, was observed adopted in Dang district of the western *terai* region. In the adjoining marginal land, seasonal crops and vegetables with some banana trees were planted. In the adjoining marginal land, seasonal crops and vegetables with some banana trees were also planted. According to the farmer, tree growing and bee farming can easily be combined because both are sustainable on land, both are less labor intensive, beehives require very little space and bees can forage in a radius of 4 to 5 km.



Figure 18 Bee farming in conjunction with *Tectona grandis* and *Paulownia tomentosa*

9. Agrosilvifishery

9.1 Fish along with *Eucalyptus camaldulensis*, *Tectona grandis* and seasonal crops

Eucalyptus camaldulensis, *Tectona grandis* and lentil were planted in conjunction with fish farming. The trees and seasonal crops planted around the dyke or border in the random mixed pattern; Farmers believed silvo-fishery is more beneficial than only fish farming as the production of multiple products, which ultimately increase the income. This practice is widely adopted in the western and eastern *terai* region of Nepal.



Figure 19: Fish along with *Eucalyptus camaldulensis*, *Tectona grandis* and seasonal crops.

Agroforestry Systems and Practices in Mid-hill Region of Nepal

7 agroforestry systems and 22 agroforestry practices are observed in visited districts of mid-hills of Nepal which are described in brief as follows:

1. Agrisilviculture

1.1 Tea under *Alnus nepalensis*

Tea was planted under *Alnus nepalensis*, *Paulownia tomentosa*, *Michelia champaca*, *Rhododendron arboretum*, and *Taxus wallichiana* in a random mixed pattern. This agroforestry practice was one of the major farming systems of Nepal with tea as the major crop. The tree species has the function of shelter provider for the major crop. Therefore, the trees were rarely harvested. This practice was widely adopted in Dhankuta, Illam and hilly parts of Jhapa districts of the eastern region of Nepal. This agroforestry practice was tea-based commercial agroforestry practice.



Figure 20: Tea under *Alnus nepalensis*

1.2 Cardamom under *Alnus nepalensis*

Cardamoms were planted under *Alnus nepalensis* generally in a random mixed pattern or cardamoms as alley crop and *Alnus nepalensis* in terrace risers. Cardamom based commercial agroforestry practice found widely adopted in the eastern, central and western region, basically in Dolakha, Sindhupalchowk, Kavrepalanchok, Kaski, Syangja, Lamjung, Illam and Panchthar districts. In Panchthar, the farmer was found to incline towards fruit trees and planning to replace *Alnus nepalensis* to get multiple benefits of fruits and timbers. Generally, *Alnus nepalensis* was grown naturally and cardamom was planted under the *Alnus nepalensis*.



Figure 21 : Cardamom under *Alnus nepalensis*

1.3 Cardamom along with *Thysanolaena maxima*, *Elaeocarpus ganitrus*, *Alnus nepalensis*, *Schima wallichii* and fodder tree species

Cardamoms and *Thysanolaena maxima* were planted under *Elaeocarpus ganitrus*, *Alnus nepalensis*, *Schima wallichii* and fodder tree like *Ficus* species in random mixed pattern or cardamoms and *Thysanolaena maxima* as alley crop and other trees in terrace risers. Cardamom and *Thysanolaena maxima*, *Elaeocarpus ganitrus* based commercial agroforestry practice was found widely adopted in Bhojpur, Illam and Panchthar districts.



Figure 22 Cardamom along with *Thysanolaena maxima*, *Elaeocarpus ganitrus*, *Alnus nepalensis*, *Schima wallichii* and fodder tree species

1.4 Cardamom and Coffee under *Alnus nepalensis*

Cardamom and coffee were grown together with *Alnus nepalensis*, *Schima wallichii*, *Castanopsis indica*, *Cinnamomum tamala* and orange in random mixed pattern. *Alnus nepalensis*, *Schima wallichii* and *Castanopsis indica* were naturally grown, whereas *Cinnamomum tamala* and orange were planted. Cardamom, coffee and orange were grown for commercial use, whereas other tree species for livelihood subsistence. This agroforestry practice was widely adopted in Syanja and Kavrepalanchowk districts.



Figure 23: Cardamom and Coffee under *Alnus nepalensis*

1.5 Coffee under multipurpose tree species

Coffee was planted under *Choerospondias axillaris*, *Michelia champaca*, *Toona ciliata*, *Melia azedarach* and *Castanopsis indica*. The tree species were naturally grown; whereas coffee was planted. The tree species were used for livelihood subsistence, whereas coffee for commercial

use. The falling leaf of *Melia azedarach* worked as pesticides for the enrichment of coffee plants. This coffee based commercial agroforestry practice was widely adopted in Kaski and Lamjung districts of western region of Nepal.



Figure 24 Coffee under multipurpose tree species

1.6 Coffee, maize and seasonal vegetables under *Elaeocarpus ganitrus*

Coffee was planted under *Elaeocarpus ganitrus* in the random mixed pattern along with cereal crops and seasonal vegetables. This agroforestry practice occupied three vertical strata of land; the seasonal crops and vegetable cover lower stratum, coffee cover middle stratum and elaeocarpus covers the upper stratum. The seasonal crops and vegetables produced in the farm were used for livelihood subsistence, whereas coffee and elaeocarpus for commercial use. This coffee and elaeocarpus based commercial agroforestry practice were adopted in Sindhupalchowk, Ramechhap and Dolkaha district of central Nepal.



Figure 25: Coffee under multipurpose tree species

1.7 *Cinnamomum tamala* along with agricultural crops

Cinnamomum tamala was inter-cropped with seasonal agricultural crops and planted as a hedgerow. In some farm, the agricultural crops were cultivated in terrace whereas *Cinnamomum tamala* in terrace border and terrace riser. Cinnamomum based agroforestry practice was widely adopted in Syangjya, Kaski and Palpa district of western region of Nepal.

1.8 *Thysanolaena maxima* along with *Cinnamomum tamala*

Thysanolaena maxima was planted along with *Cinnamomum tamala* in a different spatial pattern. Generally, *Thysanolaena maxima* was planted on terrace riser whereas, *Cinnamomum tamala* around the terrace border as well as in terrace riser. Both *Thysanolaena maxima* and *Cinnamomum tamala* were planted for commercial use. This agroforestry practice was widely adopted in Palpa and Syngjya district of the western region of Nepal.

1.9 Kiwi, cardamom and chiraito along with *Taxus wallichiana*, *Elaeocarpus ganitrus*, *Michelia Champaca*.

The kiwi was planted at the interspace of about 5m and to utilize the interspace cardamom was planted, whereas *Taxus wallichiana* *Elaeocarpus ganitrus*, *Michelia champaca* and *Swertia chirata* were planted around the border of the field. This agroforestry practice were occupied the whole vertical strata of the land. This agroforestry practice was found widely adopted in the Illam district of the eastern region. All the products on the farm were for commercial use.



Figure 26: Kiwi, cardamom and chiraito along with *Taxus wallichiana*, *Elaeocarpus ganitrus*, *Michelia Champaca*

1.10 NTFPs along with agricultural crops and tree species

A combination of non-timber forest products and medicinal plants with agricultural crops and trees were adopted in Dailekh and hilly part of Surkhet districts of the western region. *Zanthoxylum armatum*, *Juglans regia*, *Valeriana jatamansi* and *Swertia chirayita* along with *Rhododendron arboretum* and *Alnus nepalensis* were planted in random mixed pattern. The *Rhododendron arboretum*, *Alnus nepalensis*, *Valeriana jatamansi* and *Swertia Chiraita* were naturally grown on terrace riser whereas, *Zanthoxylum armatum*, *Juglans regia* and apples along with potato and seasonal crops were planted on the terrace in a random mixed pattern.



Figure 27: NTFPs along with agricultural crops and tree species

2. Hortosilvipastoral system

2.1 *Swertia chiraita*, *Zanthoxylum armatum* along with fodder and fruit trees

Swertia chiraita, *Zanthoxylum armatum*, *Quercus leucotrichophora*, *Myrica esculenta*, *Cinnamomum tamala*, *Juglans regia* and *Choerospondias axillaris* were planted occupying three vertical layers. *Swertia chiraita* and *Zanthoxylum armatum* formed lower strata, *Quercus leucotrichophora*, *Myrica esculenta*, *Cinnamomum tamala* formed the middle strata and *Juglans regia* and *Choerospondias axillaris* formed the upper strata.



Figure 28: *Swertia chiraita*, *Zanthoxylum armatum* along with fodder and fruit trees

2.2 Multipurpose trees, fodder trees, fruit trees, Grasses along with livestock

Napier, mulato, stylo, guinea, C4 and tatela grasses were planted in terraces or alleys along with orange trees in the random mixed pattern, whereas *Schima wallichiana*, *Michelia champaca*, *Litsea monopetala*, *Artocarpus lakoocha* and *Garuga pinata* were planted in terrace risers. Besides this, cattles and goats also raised in a cut and carry system. This cut and carry based commercial agroforestry practice was adopted in Tanahu and Lamjung districts.



Figure 29: Multipurpose trees, fodder trees, fruit trees, Grasses along with livestock

3. Agrosilvipastoral system

3.1 *Thysanolaena maxima* along with fodder trees and livestock

Thysanolaena maxima was planted under naturally grown *Ficus semicordata*, *Litsea monopetala* and *Alnus nepalensis* in the random mixed pattern. *Thysanolaena maxima* was planted on terraces and other fodder tree species in terrace risers. *Thysanolaena maxima* was planted for commercial purpose, whereas fodder tree species were used to feed the livestock in cut and carry system. This agroforestry practice was found in leasehold forest of Sindhuli and Tanahun districts.



Figure 30: *Thysanolaena maxima* along with fodder trees and livestock

4. Agrosilvihorticulture system

4.1 NTFPs along with fodder and fruit trees

Thysanolaena maxima was planted under *Cinnamomum tamala*, *Quercus leucotrichophora*, *Myrica esculenta* and *Choerospondias axillaris* in the random mixed pattern. Generally, the tree species were in terrace border and terrace riser whereas, *Thysanolaena maxima* in the terrace and/or terrace risers. *Valerian Jatamansii*, *Swertia Chiraita* and *Zanthoxylum Armatum* were naturally grown in the same land area. In this practice, *Thysanolaena maxima* was the major crops focused planted for commercial purpose. This agroforestry practice was adopted in Baitadi district of the far western part of Nepal.



Figure 31 NTFPs along with fodder and fruit trees

4.2 Cardamom and *Cinamomun tamala* along with *Elaeocarpus ganitrus* and banana

In this cardamom and *Cinnamomum tamala* based agroforestry practice, the cardamoms were planted under *Cinnamomum tamala*, *Elaeocarpus ganitrus* and banana in the random mixed pattern or in intercropped manner. This is a commercial agroforestry adopted in Palpa and Syangja district of western region.



Figure 32 Cardamom and *Cinamomun tamala* along with *Elaeocarpus ganitrus* and banana

5. Home Garden

5.1 Seasonal vegetables, fruit trees along with multipurpose trees

Vegetables, fruit trees and multipurpose tree species were planted simultaneously and sequentially in the same piece of land. This agroforestry practice occupied different vertical strata of land. Seasonal vegetable covered lower stratum, fruit trees covered middle stratum, and multipurpose tree species covered upper stratum. The potatoes, spinach, chilli, turmeric and zinger were cultivated along with guava and orange in the random mixed pattern, whereas *Schima wallichii*, *Castonopsis indica* and *Choerospondis axillaris* around the border of the field. The multipurpose trees were naturally growing, whereas fruit trees were planted. All the products of the farm were used for livelihood subsistence. This agroforestry practice was widely adopted in both *terai* and mid-hills however, the species combination varied. Generally, this agroforestry practice was very common in the homestead.



Figure 33: Seasonal vegetables, fruit trees along with multipurpose trees

6. Silvopastoral system

6.1 *Santalum album*, *Ziziphus budhensis*, *Schima wallichiana*, *Litsea monopetala*, *Ficus semicordata*, *Toona ciliata* and grasses along with goat farming

Santalum album, *Ziziphus budhensis*, *Schima wallichiana*, *Litsea monopetala*, *Ficus semicordata*, *Toona ciliata* were planted along with grasses in the random mixed pattern. Along with tree species and grasses, goats were also raised in the same piece of land. *Santalum album*, *Ziziphus budhensis* were artificially regenerated whereas *Schima wallichiana*, *Litsea monopetala*, *Ficus semicordata* and *Toona ciliata* were naturally grown. The tree species were grown in the terrace and terrace risers, whereas the grass species bhatamase, malato, and napier were under the trees. The *Santalum album* and *Ziziphus budhensis* were the commercial species of the farm. The fodder tree species and grasses were used to feed the goats of the farm. This agro-forestry practice was adopted in the Kaverpalanchowk and Pyuthan districts.



Figure 34 : *Santalum album*, *Ziziphus budhensis*, *Schima wallichiana*, *Litsea monopetala*, *Ficus semicordata*, *Toona ciliata* and grasses along with goat farming

7. Hortiagriculture system

7.1 Mango and banana along with maize

Combination of maize, mango and banana was observed in Makawanpur and Bhojpur districts. Mango and banana were at the boundary whereas, maize was cultivated at the center. Maize were consumed for household purpose while mango and banana were sold in the market.

7.2 Pear along with maize and seasonal vegetables

Maize and potatoes were grown under the pear trees. The pear trees were planted around and in the field and maize and seasonal vegetables were cultivated under those trees. This practice was observed in Kathmandu and Kaveplanchowk districts of central region of Nepal.



Figure 35: Mango and banana along with maize

7.3 Seasonal crops and vegetables under orange and sweet orange

Seasonal crops and vegetables were intercropped with orange and sweet orange in random mixed pattern. The major component of the farm was orange and sweet orange. The crops and vegetables were only used for household use whereas, orange and sweet oranges were commercialized. This agroforestry practices were widely adopted in Ramechhap and Sindulu and Tanhun districts.



Figure 36: Seasonal crops and vegetables under orange and sweet orange

7.4 Coffee under orange, banana, walnut and jackfruit

Seasonal vegetables under coffee and oranges forming three vertical strata were practiced in Syangja and Kaski districts. Similarly, jackfruit, banana, walnut and jackfruit were also grown along with this practice. The major components of the farm were coffee and orange and other fruits products were also commercialized. Similar practice of Coffee farming was also observed in Nuwakot district.



Figure 37 Coffee under orange, banana, walnut and jackfruit

7.5 *Zanthoxylum armatum* along with orange and agriculture crops

Zanthoxylum armatum was planted along with orange in random mixed pattern and seasonal crops and vegetables were cultivated under those species. *Zanthoxylum armatum* planted in the bunds and boarder of sloping land and terraces along with orange. *Zanthoxylum armatum* was the major component of the farm as it has good national and international markets there-after orange. The agriculture crops and vegetable products were used for livelihood subsistence but some farmers have also commercialized them on the local scale.



Figure 38: *Zanthoxylum armatum* along with orange and agriculture crops

CHAPTER: FOUR

PROBLEMS, CHALLENGES AND OPPORTUNITIES

4.1 Problems and challenges of agroforestry development in *terai* and mid-hills

Agroforestry has a very high potential to contribute in social, financial and natural capitals; and hence in local and national prosperity. This study has explored various problems and challenges that need to address for the development of agroforestry systems and practices in Nepal. Most of the farmers faces shortage of farm-workers because of migration of villagers to urban and foreign countries for better job opportunities and services. In most of the villages only old and children are left and are unable to continue the agroforestry system they are practicing from many generation. It is the fact that agroforestry is more labor intensive than plantation of single crops; in most of the *terai* region, farmers are inclined towards the plantation of trees only rather than agroforestry practices because of shortage of farm worker, shortage of water, lack of technical know-how and immigration of landholder to urban area. Farmer explained it is quite easy to plant forest crop and let them to grow without caring for water, cleaning, etc.

Growing agriculture and forest crops needs the understanding of silviculture and management aspects of the trees and crops. The technical knowhow of the farmers are limited; for example in the Banke and Bardia districts of western *terai*, most of the farmers import seedlings of *eucalyptus* and *tectona* from Indian nurseries, to sell more seedlings the nursery owner suggest farmers to plant seedlings in closer spacing, resulting in less return both from forest and agriculture crops. So the concerned organization needs to disseminate information and technical understanding to the farmers for better returns from the field. In addition, most of the farmers have fear of casting shade by the trees and hamper the growth of the agriculture crops where agriculture crops are the first priority of the farmers. In such dilemmas, technical support from concerned authorities is being lacked. Good quality and vigor seedlings of forest and horticulture crops are not easily available. If they are available, it is difficult to assure of their quality. Farmers were concerned about the easy availability and certified seedlings of their interest.

Species combination plays important role to enhance the production and protection capacity of the agroforestry farm. The study found that appropriate species combinations are mostly overlooked. Most of the farmers have planted the tree species which are easily available or freely distributed by the DFO and other organizations without addressing the need of the farmers and species suitability at the particular locality. Similarly, the species combination were not observed for example; the species that shade leaves during agricultural period and that flourish green leaves during the winter fodder deficit season when farmers are in need of fodder trees to feed their livestock.

Many agroforestry practices especially tea, coffee, and cardamom based are shifting from subsistence to commercial based practices in western and eastern part of Nepal. In the same time, farmers were concerned about the marketing of these products. There is lack of two way market linkages and buy back guarantee of the agroforestry products which discourage the farmers to continue the practices in the long run. In addition, the tedious and long bureaucratic hassles to get the release permits and value added tax imposed to the forestry crops have also discouraging and bringing frustration among the farmers.

Return on investment from planting trees takes many years and it is long term investment with risk of failure from environmental, social and technical reasons for example; insect and pest infestation may destroy the trees. Farmers were concerned about the insurance of agroforestry crops which encourage them to adopt the system with full confidence.

Most of the farmers especially in mid hills have very small land holding size which limits the adoption of agroforestry practices to subsistence farming practice only.

4.2 Opportunities of Agroforestry development in *terai* and mid hills

Even there are some barriers for agroforestry development; there are tremendous opportunities for agroforestry development and scaling up the system in mid-hills and *terai* region of Nepal. There is a growing evidence that agroforestry is more profitable than forestry alone, and may have several climatic and social advantages for the farmers as well as for the local and national prosperity. Therefore, it is foremost to create an enabling environment for promotion and to widen the opportunity of agroforestry in mid-hills and *terai* region of the country.

In Nepal, 0.65 million including 9502 hectare, 501848 hectare and 1,993,302 hectare in *terai*, *chure* and midhills respectively are other wooded land (DFRS/FRA, 2015). Therefore, it has a tremendous opportunity to integrate agricultural, forest and horticultural crop in other wooded land.

In Nepal, recent trends of timber and fuelwood supply shows that softwood timber and fuel wood are supplied from private farmlands and marginal lands than forests (DoF,2015).So, so it has a great opportunity to extend the commercial and systematic agroforestry in those lands contributing to the income and livelihood of millions of people together with an opportunity to easing timber supply system.

The land-use policy, 2015 has a provision of no abandoned land, however, abandoned land in mid-hills and *terai* are increasing every day due to labor shortage and migration. In this circumstance, there is a huge opportunity to develop agroforestry in abandoned lands. Every year, many *terai* and hill farms are converted into degraded land due to natural hazards such as landslides, erosion, flooding, river course change, etc. In such land area, agroforestry can be developed as rehabilitation measures and greening the hills and plains and can be means of rural development as trees and crops can be managed simultaneously and guarantee the sustainability of the system along with its contribution in household livelihoods.

Agroforestry is a biodiversity-friendly land-use system that plays a strategy for wildlife corridors and connectivity development. Agroforestry crops help in carbon sequestration and provide multiple benefits to the farmers. Thus, it has a great potential to contribute to climate change mitigation.

CHAPTER: FIVE
CONCLUSION AND RECOMMENDATION

CONCLUSIONS AND RECOMMENDATIONS

In two physiographic region of Nepal, 12 agroforestry systems and 42 practices are explored. *Terai* region comprises of 9 agroforestry systems and 20 practices and mid hills comprises of 7 agroforestry systems and 22 agroforestry practices.

Agroforestry system and practices in *terai* region are:

S.N	Agroforestry systems	Agroforestry practices
1	Agrisilviculture	<i>Camelia sinensis (Tea)</i> under <i>Albizia procera</i> and <i>Dalbergia sissoo</i>
		Turmeric and ginger under <i>Eucalyptus camaldulensis</i>
		Seasonal agricultural crops under <i>Tactona grandis</i>
		Seasonal agricultural crops along with mixed tree species
2	Hortisilviculture	Banana along with <i>Eucalyptus camaldulensis</i> and <i>Tectona grandis</i>
		Mango along with <i>Eucalyptus camaldulensis</i> and <i>Tectona grandis</i>
		Avocado and pomegranate along with tree species
		<i>Eucalyptus camaldulensis</i> and <i>Mangifera indica</i> along with asparagus, citronella, palmarosa and mentha
3	Hortiagriculture	Fruit trees along with seasonal agricultural crops
4	Agrisilvihorticulture	Agricultural crops along with banana and tree species
		Fruit trees and agricultural crops along with <i>Tectona grandis</i> , <i>Shorea borneensis</i> and <i>Dalbergia sissoo</i> .
		Fruit trees, agricultural crops and seasonal vegetables along with eucalyptus
		Mango and agriculture crops along with <i>Eucalyptus camaldulensis</i> , <i>Tectona grandis</i> , <i>Populus</i> species, <i>Melia azedarach</i>
5	Agrosilvipastoral	Agricultural crops along with <i>Acacia catechu</i> , <i>Elaeocarpus ganitrusa</i> and pig farming.
		Agricultural crops, tree species along with grasses and livestock
6	Silvofishery	Fish farming in conjunction with <i>Eucalyptus camaldulensis</i> , <i>Tectona grandis</i> , <i>Mango</i> and <i>Dalbergia sissoo</i>
		Fish farming along <i>Tectona grandis</i> , <i>Paulownia tomentosa</i> , and <i>Shorea borneensis</i>
7	Agrosilvifishery	Fish along with <i>Eucalyptus camaldulensis</i> , <i>Tectona grandis</i> and seasonal crops.

8	Apiculature	Bee farming in conjunction with <i>Tectona grandis</i> and Paulownia
9	Agrohertosilvopastoral	Agricultural crops and Areca catechu along with <i>Tectona grandis</i> , <i>Eucalyptus camaldulensis</i> , <i>Elaeocarpus sphaericus</i> , <i>Shorea borneensis</i> , <i>Acacia catechu</i> , and livestock

Similarly, agroforestry system and practices in mid-hill are:

S.N	Agroforestry systems	Agroforestry practices
1	Agrisilviculture	Tea under <i>Alnus nepalensis</i>
		Cardamom under <i>Alnus nepalensis</i>
		Cardamom along with <i>Thyrsanolaena maxima</i> , <i>Elaeocarpus ganitrus</i> , <i>Alnus nepalensis</i> , <i>Schima wallichii</i> and fodder tree species.
		Cardamom and Coffee under <i>Alnus nepalensis</i>
		Coffee under multipurpose tree species
		Coffee, maize and seasonal vegetables under <i>Elaeocarpus ganitrus</i>
		Cinnamomum tamala along with agricultural crops
		<i>Thyrsanolaena maxima</i> along with Cinnamomum tamala
		Kiwi, cardamom and Chiraito along with <i>Taxus wallichiana</i> , <i>Elaeocarpus sphaericus</i> , <i>Michlia champaca</i>
NTFPs along with agricultural crops and tree species		
2	Hortosilvopastoral	<i>Swertia chiraita</i> , <i>Zanthoxylum armatum</i> along with fodder and fruit trees
		Multipurpose trees, fodder trees, fruit trees, grasses along with livestock
3	Hortiagriculture	Mango and Banana along with Maize
		Pear along with maize and seasonal vegetables
		Seasonal crops and vegetables under orange and sweet orange
		Coffee under Orange, Banana, Walnut and Jackfruit
		<i>Zanthoxylum armatum</i> along with orange and agriculture crops:
4	Home garden	Seasonal vegetables, fruit trees along with multipurpose trees
5	Silvopastoral	<i>Santalum album</i> , <i>Ziziphus budhensis</i> , <i>Schima wallichiana</i> , <i>Litsea monopetala</i> , <i>Ficus semicordata</i> , <i>Toona ciliata</i> and grasses along with goat farming.
6	Agrosilvihorticulture	NTFPs along with fodder and fruit trees
7	Agrosilvipastoral	<i>Thyrsanolaena maxima</i> along with fodder trees and livestock
		Cardamom and <i>Cinamomun Tamala</i> along with <i>Elaeocarpus ganitrus</i> and Banana

Agroforestry systems and practices vary in *terai* and mid-hill region and within the region vary with location. Mostly, traditional agroforestry practices are adopted in *terai* and mid-hills however, gradually shifting to commercial practices.

In *terai*, mostly the agroforestry practices were farm-based commercial, focusing on timber species such as eucalyptus, tectona, mango and poplar. Farmers are gradually shifting towards the plantation of fast-growing and high value timber species such as pauwolnia in the wood lots rather than mixing with agriculture crop species with the aim of getting more benefits with less effort.

The central parts of mid-hills are dominated by farm-based subsistence practices with combination of fruits and fodder trees whereas, farm-based commercial practices are adopted in western and eastern mid-hills dominated by tea, coffee, cardamom, red pepper and some other minor forest products.

The agroforestry practice in *terai* and midhills are multilayers, with a wide variety of species and moderate to dense associations with no organized planting arrangement. The density of the vegetation and the richness of species are generally higher in eastern than in western.

The agroforestry practices in *terai* and mid-hills have not received the attention that they deserves. Some recommendations have been prescribed for the development of agroforestry in general and especially in *terai* and mid-hills of Nepal. The farmers are practicing agroforestry with their traditional knowledge and have limited knowledge on management of the complex integrated system. So, capacity building and awareness rising on agroforestry can contribute in development of agroforestry in the region. Similarly, assurance of the good quality seedlings and technical supports from concern authorities along with subsidy facilities in seedling, equipments, suitable combination of species and buy back guarantee of agroforestry products with minimum legal hassles can increase agroforestry practice in private and public lands.

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