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Agro-forestry for Enhancing Adaptation of Local Community against Drought in Hilly Region of Nepal

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Abstract – **Nepal is prone to adverse effects of climate change including droughts, floods, landslide, etc. Vulnerabi--lity of communities residing in mountainous areas to climatic hazards, mainly drought, has compelled them to modify their livelihood through various approaches like agroforestry. Agroforestry system, regarded as an efficient means to building resilience towards climate stress in recent years, can address food security, climate change vulnerability, along with the adaptation needs of local inhabitants. This research was carried out in Likhu Rural Municipality, ward number 2 (Ramechhap district) to examine the role of agroforestry system in enhancing adaptation during drought and assessing its effectiveness as an adaptation strategy through various Participatory Rural Appraisal (PRA) tools. More than 90% of respondents believed that trees on farmland helps to improve the quality of soil and water. Similarly, majority farmers (>80%) with trees on their farms mentioned that agroforestry aided them in terms of financial capital by curtailing risk of being in debt. Local community considered agroforestry as an integral part of their adaptive plan during prolong drought period, where trees are mostly grown on terrace raisers, home gardens, etc. Presence of species like Alnus nepalensis, Litsea monepetala, Schima wallichii, Ficus species, etc., and products from them suggests that agroforestry system is appropriate tool to accretion of waning productivity and adaptation again--st climatic hazards. The results also indicate that agroforestry can be a viable approach to combat climate change, which needs to be reflected in local adaptation plans.**

Keywords – **Adaptive Capacity, Agroforestry System, Climate Change and Resilience.**

I. Introduction

Climate change is one of the critical global challenges faced by humankind [1] with no exception to communities living in mountainous countries like Nepal [2] and has potentiality to convert probable natural hazards to severe natural disasters [1], [3] such as floods, prolonged drought, crop failures, outbreak of pandemic diseases etc. [4]; which are more frequent throughout last decade [2], [5]. In Nepal, it is predicted that current frequency of hydrometeorologi--cal extreme events such as drought, storms, floods, inundation, landslides, soil erosion is likely to be increased [6] in coming years creating pressure on livelihood of local communities [7].

This small country sees more than 85% of its rainfall during the four monsoon months (June to September) [8]. In recent years, changes in monsoon patterns are conspicuous [9]: especially timing of rainfall, its frequency, duration and intensity [2], [5]. Due to changes in pattern of precipitation, temporal variability of water availability is very high [2], [10] i.e. the problem of excess water during the monsoon and water scarcity during the dry season [9]. Signs of changes in date of onset and retreat of the monsoon as well as the number and frequency of extreme precipitation events [2], [8], [11] are prominent, where intermittent drought like situation during monsoon season is frequent and getting severe every year [5]. Among various hazards and disasters associated to climate change, drought is one of the most complex [12] and least understood natural hazards, affecting more people than any other [13]. Mostly, drought first appears when there is below-average rainfall within normal precipitation pattern [12], [14], [15], which can develop as an extreme climatic disaster and turn into hazardous phenomenon [2], [5] for mountainous communities and water dependent sectors [15]. The social, environmental and economic losses associated with drought are increasing continuously [8], [9], where impacts of droughts are non-structural and rather ancillary [16].

Farmers, depending on rain-fed agriculture system for agriculture, experiences greater level of drought impacts [5], [17] and their livelihood gets highly affected [11]. Rural communities are using various local techniques and knowledge in adapting against adverse impacts of climate stresses like drought, flood, landslides [18]. However, adapted technologies and practices are mostly forest and/ or tree based like bamboo plantation, plantation of mixture of trees and crops, forest protection, bioengineering etc. [6], [19]. Similarly, adaptation strategies in agriculture land have been mostly evolved around changes in species composition, plantation of drought resilient crops or managing water efficiently [7], [10]. Among various farm based adaptation practices agroforestry system includes both agriculture and forest trees in same land that helps in diversification of products [8, 20].

Primary aim of practicing agroforestry system is to meet the present and future requirement of fodder, fuel wood, timbers etc. [17], [21]. But recently, this system has received considerable attention due to the evidence that trees and crops could be managed simultaneously [22] assuring the sustainability of agriculture crops and enhancing resilience of system against extreme climatic hazards [16], [23] especially in mountainous areas. Trees and/ or shrubs on farmland and in landscape may occur as individual stand [24], in rows, as woodlots etc. [25] that can characterize the present forest types before the initiation of agricultural system or associated agriculture crops after clear felling of the area [24], [26]. Depending on the climatic, topographic, environmental and socio-economic setting of the locality [22], [27] and adaptation of the trees species, different types of agroforestry system is developed and their function evolves to a particular ecosystem [26], [28].

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Agroforestry practices can reverse or slow down land degradation process [7], [17], sequestrate carbon from atmosphere [18] and secure livelihoods through economic benefits derived from it [29]. Despite of these multi-functionalities of agroforestry practices [30], it is often neglected from recommendation for ensuring food security [16] and enhancing local community resilience due to number of reasons including performance of system[31], political and socio-economic practices of the community and emphasis by government on particular system [20], [21]. However, in recent years, practices of including agroforestry system under adaptation plans [10] are initiated and practiced by many farmers around the globe [16, 20]. In this regards, this study aims to evaluate the role of agroforestry in enhancing the resilience of local communities against drought in hilly areas of Nepal, where the role of various species, services and the values derived from agroforestry system is measured.

II. Study Area

This study was carried out in Likhu Gaupalika, ward no. 2 of Ramechhap district in Nepal. This area was previously known as Saipu VDC. It is situated in between 27.4333^0 North latitude and 86.2500^0 East longitude. According to Nepal census 2011, this former VDC has total population of 2,876 residing in a total of 616 households [32]. This ward is extended form Likhu river basin comprising of hill *Shorea* forest to *Quercus* forest in northern side [33]. There are nine community forests and a large patch of private forest as fallow land. Fuelwood is major source of energy in this ward [34] which is either extracted from private land or community forestry.

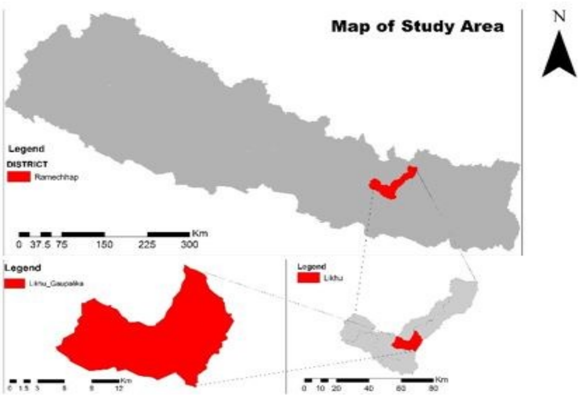

Fig. 1. Map of Study Area.

III. Methodology

Both qualitative and quantitative data for this study were collected in January 2018. Semi structured questionnaire was used to assess the importance of agroforestry in drought period and identify the values and services produced from agroforestry system. Individual semi-structured question--naire survey was conducted for identifying the major agroforestry system, species location and combination, whereas informal meetings and key personal interviews were conducted to assess the values and services from agroforestry system and individual stand (tree) in the system. Altogether 61 households were sampled for this study (90% CI), where simple random sampling was adopted to determine sampling unit. Secondary information were collected through various reports, VDC profile, LDRMP etc. and were fitted into the objective of the study for further analysis. Information collected through both primary and secondary sources were analyzed with R for statistical analyses and presented in tables, bar charts, tables etc.

IV. Results

In the study area about 87% of the total sampled household (Fig. 2) were observed adopting some form of agroforestry system.

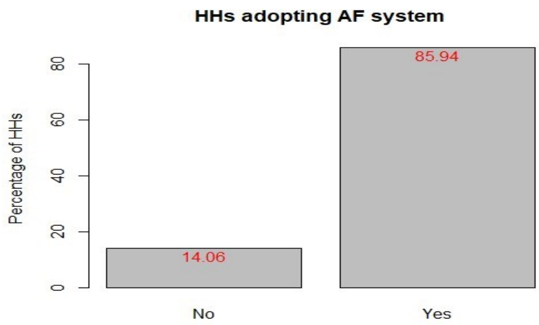

Fig. 2. Status of households adopting agroforestry system.

Around 86% of the total HHs adopting agroforestry system, have adopted home garden system mostly with fodder and citrus species followed by plantation of trees in and around farmland covering 84%. Around 32% of the HHs have adopted commercial crops under and silvo-pastoral system that accounts for around 24% as shown in Table I. This study showed that the majority of sample HHs were practicing more than one agroforestry system and species combination depending on types of farmland. Among four different agroforestry practices observed in the study area, the traditional system is adopted where trees are planted for various other purpose rather than financial except for commercial crops under trees.

Table I. Types of agroforestry system adopted by households and species combination.

Types of AF system	Percentage of HHs	Species Combination
Home Garden	86.49	*Ficus semicordata*, *Ficus infectoria*, *Bauhinia purpurea*, citrus species, *Bauhinia variegata* along with vegetables
Trees in and around Farm Land	83.78	*Schima wallichii*, *Choerospondias axillaris*, *Alnus nepalensis*, Bamboo, *Litsea monopetala*, *Ficus semicordata*, *Ficus roxburghii*, *Ficus nemoralis* along with cereal crops
Commercial crops under trees	32.43	*Alnus nepalensis*, *Madhuca longifolia*, Maleto along with cardamom
Silvo-pastoral	24.32	*Schima wallichii*, Lakuri, *Ficus* species in fallow land

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Types of species present in agroforestry systems were evaluated in this study where 84% of the sample HHs have *Schima wallichii* in their agroforestry system. Similarly, *Alnus nepalensis* (61%) is the second preferred species. Fodder species like *Ficus roxburghii*, *Litsea monopetala*, *Ficus semicordata*, Fosro etc. were present in a noticeable amount, however fruit species such as *Choerospondias axillaris*, *Artocarpus heterophyllus* etc. were also noticed in agroforestry system (Fig. 3).

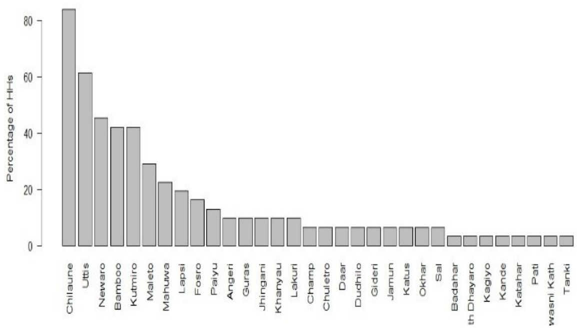

Fig. 3. Different species of trees in agroforestry system.

Most of these trees are located in terrace raiser (84%), near stream or water resources (43%), border of land (41%), water scarce areas (24% HHs), fallow land (38% HHs), and home garden (in 41% HHs) (Graph 3). Field observation showed that fodder and fruit species like Litsea monopetala, Choerospondias axillaris, and Bauhinia purpurea were dominant in terrace raiser and species like bamboo and other timbers were mostly present in water scarce areas or border land but not in the home garden.

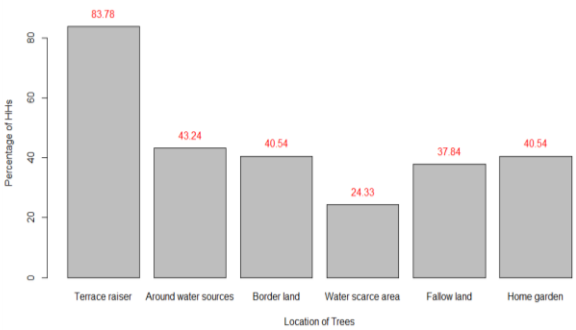

Fig. 4. Location of trees in agroforestry system.

Around 42% of the respondents have been collecting fodder as agroforestry products mainly from species like *Litsea monopetala*, *Ficus roxburghii*, *Ficus semicordata* etc. Similarly, this system is equally used for timber and firewood collection/ extraction where the most preferred species are *Schima wallichii*, *Alnus nepalensis* etc. Less than 10% of sample HHs were observed practicing agroforestry only for fruit production. Only few HHs seemed to practice agroforestry for multipurpose use like fruit production, fodder production etc. (Table II).

Table II. Purpose of practicing along with major species

Purpose	Percentage	Main species
Fodder	42.43	*Litsea monopetala*, *Ficus roxburghii*, *Ficus hispida*, *Prunus serrulata*, *Ficus semicordata*, Bamboo, *Boehmeria rugulosa*
Timber (firewood)	42.42	*Schima wallichii*, *Alnus nepalensis*, *Lyonia ovalifolia*, *Madhuca longifolia*, *Syzygium cumini*
Fruit	9.09	*Choerospondias axillaris*, *Juglans regia*, *Psidium guajava*, *Magnifera indica*
Multipurpose (mixture of all three)	6.06	All species

The major products obtained from the agroforestry system includes fruit (42 HHs), fuelwood/firewood (49 HHs), fodder (55 HHs), timber (48 HHs), and medicine (18 HHs) (Fig. 5).

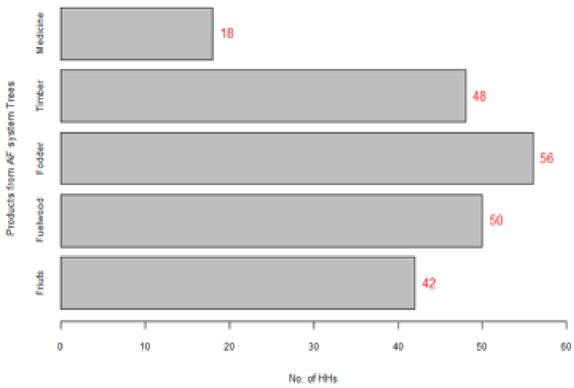

Fig. 5. Products (values) from agroforestry system.

39 respondents were unaware and 22 respondent believed that trees in agroforestry system help in reduction in carbon emission and carbon sequestration. 25 HHs believed, 16 HHs remained neutral and 20 HHs denied the role of TOFs as wind break. Similarly, 38 people interviewed accepted that TOF improves water in soil whereas 4 people ignored and 19 people were neutral. The number of respondent to believe that TOFs maintain biodiversity is 53 and 8 respondents remained unaware of this. 51 respondents were positive to TOFs maintaining water quality for which 9 were unaware and 1 was negative. 35 HHs accepted that use of trees in agricultural land enhances soil fertility but 26 were completely unaware of this. Total of 60 households believed agroforestry trees reduce soil erosion and provides shade to their farm (Fig. 6).

Table III. Major Tree species and their function in agroforestry system

Function	*Schima*	*Alnus*	*Ficus*	*Bambusa*	*Litsea*	*L ovalifolia*	*C. axillaris*	*F. hispida*	*Prunus*
Firewood/fuelwood	7	14		8		23			
Fodder	5	7	34	34	34			23	16
Fruits/vegetable			2	22			34		4
Maintains soil fertility	7	11				22			

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Function	*Schima*	*Alnus*	*Ficus*	*Bambusa*	*Litsea*	*L ovalifolia*	*C. axillaris*	*F. hispida*	*Prunus*
Maintains water quality	10		3			33	32		15
Reduces soil erosion	23	37	12	34	2		5		9
Shade to farm	34	17	11				11		
Stabilizes slope/terrace	34	34	21	31	23	31	21	9	7
Timber	31	21				14			2
wind breaks	28	9	12	34			14		

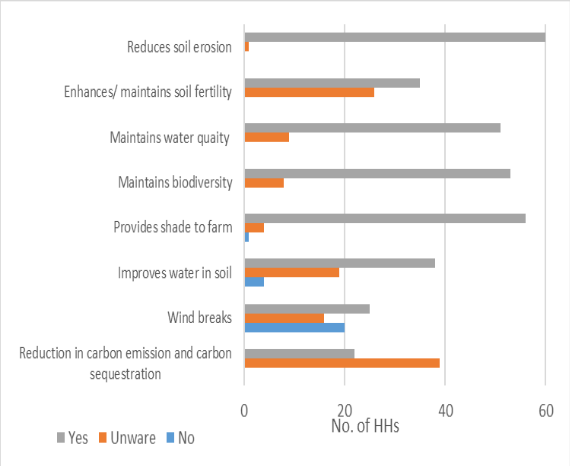

Fig. 6. Services from agroforestry system.

Function of trees in existing agroforestry system was assessed to evaluate the types of products and services produced by individual trees species. Among nine major tree species recorded in study area only few species were planted/ retain only for single purpose. Species like *Schima wallichii, Alnus nepalensis,* Bamboo were multifunctional whereas fodder trees have less function on agroforestry (Table III).

92% of the HHs sell bamboo stands whereas 86% HHs earn by selling timber. 32% of HHs rely on income through firewood while 76% HHs are benefitted by fodder. Just below 40% HHs sell fruits (Fig. 7).

About 32% HHs believed AF system to be an integral system from economical point of view during drought whereas more than 51% considered it to be less important. Around 10% were neutral and less than 3% believed AF system to be unimportant economically during drought period (Fig. 8).

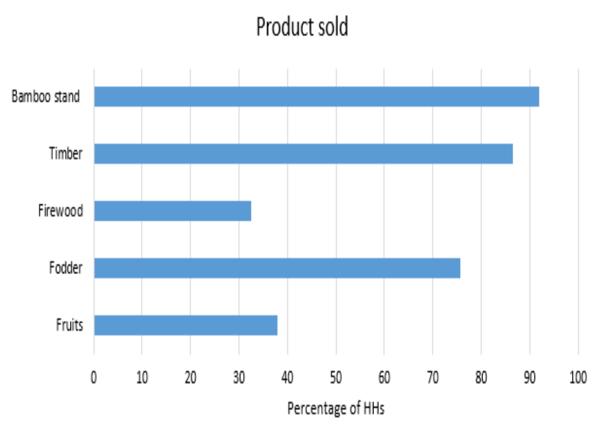

Fig. 7. Various products obtained and sold from agroforestry.

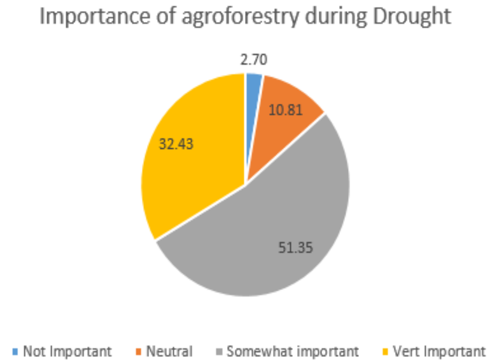

Fig. 8. Importance of agroforestry system during drought.

V. Discussion

Like Ramechhap district, highly vulnerable to climatic change [10], this VDC has also been recognized as highly stressed by various impacts of climate change like drought, flood, hailstorm etc. [33]. Among various disasters identifi--ed in Local Disaster Risk Management Plan, drought was one of the major disasters that occurs frequently in this VDC. Due to drought, people are suffering from unavailabi--lity of water for irrigation, scarcity for livestock feeding and drinking [35]. Recently frequency of drought is believed to be increasing with increasing severity.

Farmers in hilly area of Nepal have long tradition of practicing many types/ forms of the agroforestry system [36], types and choice of agroforestry system vary according to the physiographic zones, aspects, land holding, livestock holding status etc. [17], [21]. In the study area, home garden, tress in and around farmland, commercial crops under trees and silvo-pastoral system were recorded. Types and number of system practiced primarily depended on size of land holding by farmers, vulnerability to climatic stresses, demand of forest products, location of land like sloppy land, unirrigated land etc. [21], [23]. Along with agriculture, farmers in hilly area practice livestock rearing for their livelihood [21], [32], [37]. Presence of livestock in system compelled farmers to plant fodder tress in farmland especially for drought months i.e. December to February. Species like *Litsea monopetala*, *Ficus semicordata*, *Ficus roxburghii* etc. are major fodder tress retained in farmland i.e. mostly in terrace raiser, border land [16], [25],]36]. Practice of using bamboo as fodder during dry months (December-February) has developed tradition of planting bamboos in water scare area, fallow land, sloppy land etc. [29] which can be a source of income and help to reduce soil erosion [24], [31]. Species like *Alnus nepalensis*, *Schima wallichii* etc. are retained in the agroforestry system for extraction of timber and fuel wood where fuelwood is major source of energy for cooking and heating [33], [34].

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In this area few HHs are depending on community forests for fuelwood extraction, which shows that HHs dependence on trees in farm land is high.

Agroforestry system can produce wide range of products and services [25], [31]. Trees in agroforestry produces products like firewood, timber, fruits, medicines, fodder etc. [26], [34], [36], which can directly be traded. However, services such as maintaining soil fertility, reducing soil erosion, stabilizing slope, wind breaks and maintaining biodiversity are more valuable to maintain biodiversity [3], [28], [31], [38] and to mitigate the impacts of climate changes for mountainous communities [16], [24]. Trees have a substantial impacts on micro-climate where they grow [25], [26], provides shades, regulates wind speed and retains moisture in the immediate surroundings [4], [16] causing favorable environment for crowing agriculture crops. Trees based farming system not only modifies the microclimate but also stores carbon in soil and woody biomass [30], and help to reduce greenhouse gas emission from soil [3], [24]. The microclimatic effects of climate change can convey adaptation benefits to the farmers [16], [21] in hilly areas, adding resilience through enhancing productivity and diversifying the coping options available at farm level [5], [20]. The direct products supplemented by additional indirect services from the agroforestry system have been highly regarded as important by hilly farmers [36]. Local level climate change adaptation plans such as LAPA, LDRMP shows that severe impacts of climate change like drought can be mitigated through promotion of forest based activities like plantation [30], [38], [39], protection of existing forest area [35], reducing the impacts of forest fire by control burning [33], promotion of bioengineering [18], trees in and around farm land [27].

The economic importance of the agroforestry such as selling of fruits, fodder, timber etc. [22], [27] diversify the income sources of the local farmers. Commercial production of agroforestry products have not been initiated, however cardamom along with *Alnus nepalensis* have been practiced in eastern hills of Nepal [40]. Diversification of products from agroforestry have been least initiated but local communities are well informed about the potential role it can play in terms of economic return and enhancing livelihood. Agroforestry is one of the few land management strategies [16] that develops the synergies between commercial production, food security and climate change mitigation for farmers [21, 30, 36].

VI. Conclusion

Agroforestry practice has been used by community in the study area as an adaptation measure to ongoing effect of drought induced by global climate change. Mostly people have planted species like *Schima, Alnus, Litsea, Ficus* etc. The fodder species like *Bauhinia, Ficus, Litsea* etc. have contributed to fulfill the feeding requirement of livestock during the period of drought. Stall feeding using the leaves of fodder tress has reduced the grazing pressure on nearby forests and rangelands. Mostly, these trees are grown in terrace raiser and in water scarce zones. Moreover, people are using agroforestry trees as their source of income which has significantly contributed to their annual income through selling of bamboo stands, fodder, firewood/ fuelwood, timber and fruits.

Agroforestry system on the other hand plays important role in maintaining environmental variables. Most people believed that agroforestry system is efficient to carbon sequestration and maintaining soil and water quality. This system contributes well to reduction of soil erosion and maintaining biodiversity of the area. Agroforestry is also one the few land use strategies that promises strong synergy between food security and climate change mitigation and there is tremendous potentiality for agroforestry system to enhance the livelihood of local community and develop their resilience against climate induced natural disasters.

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Second B. Simant Rimal
Simant Rimal is working as a Program Officer in leading organization related to the research of Forestry and Environment sector in Kathmandu, Nepal. He is a recent graduate of Forestry Science from Faculty of Forestry, Agriculture and Forestry University, Hetauda, Nepal with major areas of research interest in Agroforestry, Climate Change, Disaster Risk Reduction and others. He has completed his undergraduate studies with the merit scholarship and studentship award throughout his study period. Also, he was awarded with the Mahatma Gandhi scholarship for completion of his high school level education from St. Xavier's Campus, Kathmandu. Besides presenting paper on conference, he is also an author to a research paper. He is the permanent resident of Bharatpur Metropolitan, Chitwan. email id: rimal.cmant@gmail.com

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Kamana Parajuli is currently pursuing her Master's degree in Forestry science in Faculty of Forestry, Agriculture and Forestry University (AFU), Hetauda, Nepal. She has completed her B. Sc. Forestry in 2018 with good academic background from AFU, Hetauda. She is passionate in research works related to forest, wild--life, NTFP's and climate change. She has award winning participation in different competitions related to forestry. Besides, she has contributed in conservation through different extension works like presentation, rally and campaigns in many occasions. She aims to rise as passionate conservationist in future and contribute to environment sector through many research works. email id: parajulikamana@gmail.com

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