



Effect of Agricultural Land Abandonment on Vegetation Composition and Soil Properties in Mid-Hills of Gorkha District, Central Nepal

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ABSTRACT

A comprehensive investigation was conducted in Ripagaun of Siranchowk-5, Gorkha using a random sampling technique by establishing 20 circular plots of 7m radius for trees, 3.5 for shrubs and 1 m for herbs species. Four different types of land use (Recently Abandoned land (RA), Short-term Abandoned land (SA), Long-term Abandoned land (LA) and Reference Forest (FO)) were investigated by calculating diversity indices, species richness and studying the soil properties. Altogether 39 plant species belonging to 24 families (3 herbs, 1 climber, 15 shrubs and 20 trees) were documented from the study area. LA showed the maximum Simpson index (0.83) while RA showed the minimum Simpson index (0.76). Furthermore, LA had the highest Shannon index followed by SA while FO showed higher Pielou evenness. The observed richness of LA was higher than that of others while SA followed suit. Notably, Asteraceae family had higher average relative abundance in SA whereas Theaceae had higher average relative abundance in SA as well as in FO and Compositae showed high average relative abundance in LA. Certain plant species like *Bidens biternata*, *Colebrookea oppositifolia* and *Rubus ellipticus* have shown a positive association with humus content, indicating their need for a substantial amount of humus in order to thrive optimally. On the other hand, *Bauhinia purpurea*, *Ficus clavate* and *Hypericum uralum* have exhibited negative correlations with humus content, suggesting their adaptation to environments with low levels of humus. Additionally, plants such as *Ageratina adenophora*, *Maesa chisia*, *Premna integrifolia*, *Rhus wallichi*, and *Agave cantala* have shown positive correlations with soil pH, indicating their preference for alkaline conditions. On the contrary, *Vitex negundo*, *Jatropha curpas*, *Sapinadus mukorossi*, *Artemisia vulgaris* have displayed negative correlations with soil pH. The findings reported herein are grounded in rigorous scientific methodology and contribute to the understanding of plant ecology in diverse land use scenarios, particularly in the specified geographic location of Ripagaun, Gorkha Nepal.

KEYWORDS: Land use, Abandoned, Abundance, Correlated, Humus content.

INTRODUCTION

Generally, land use is a complicated terms of syndromes of human activities such as agriculture, forestry, building construction which leads to the alteration of land surface processes like hydrology, biodiversity and climate. “The total of arrangements, activities and inputs that people undertake in certain land cover type” is referred to land use.^{1,2} In broad sense, land use includes the social and economic purposes of land and its management. Till today, about three-quarters of the land present on the earth surface has been altered by human beings for their different needs and demand.³ Due to the massive growth of population, agricultural land expansion, urbanization and many other human activities results to greater land acquisition rate.

Agricultural land abandonment is defined as gradual process where the farming intensity is decreased resulting in termination of farming completely.⁴ Different terms like farmland abandonment, abandoned agricultural land, under- utilized agricultural land are used interchangeably with agricultural abandonment. In recent context land abandonment has been a global topic for research as it is directly related with global scarcity of food production and demand.⁵ Many studies have been conducted on European countries, United State whereas relatively limited studies have been performed in Asian countries.⁶ China reported 28 % of abandonment land during 2000-2010⁷ and Japan reported 9.7-12.2 % during 2005-2015. The farmland abandonment has shown both positive and negative consequences on biodiversity, environment and climate. Positive consequences like improved soil properties, providing habitats for many species and promoting biodiversity as well as it reduces soil erosion.⁸ On the other hand, degradation of land and its structures, encroachment of invasive species and wildlife⁹ are some negative impacts of land abandonment.

Nepal, known as agricultural country as the people livelihood of rural communities mostly depend on farmland. The people not only depend on land for the food production but also for portraying the social status and financial security.¹⁰ It has been reported that about 37% of arable land has been abandoned in Nepal¹¹ and only 21% of land has been used for farming purposes from total country land area. In Nepal, agriculture is the major source of livelihood of more 65% of rural people, this sector is facing a serious challenge in recent time due to increment in land abandonment problems. Gross Domestic products (GDP) of Nepal has been decreased to 26% from 33% due to this issue in 2011.¹² The study conducted by Dahal, *et al.*,¹³ reveals that 47% of arable land has been abandoned in Western mid-hills (Kaski), Nepal. Some of the factors responsible for the increment of land abandonment in Nepal are migration of people, decrease of soil productivity, high cost of production, urbanization, political issues, irrigation problems, due to wild animals and unclear and insecure land tenure policy. The agricultural land abandonment has brought the serious challenges to people, economy and environment at different scale.

In overall, this study aims to explore the consequences of agricultural land abandonment on vegetation composition as well as soil properties. With various limitations on available resources especially regarding lands, it becomes crucially important for

understanding how the present arable lands are being utilized. The study may provide important new insights into ecological dynamics and biodiversity differences, and they further our understanding of the unique distribution patterns of plant taxa across different land use types.

MATERIALS AND METHODS

Study Area

Ripagaun, Siranchwok-5 of Gorkha district of Gandaki province covers 121.66 km² area and lies at an altitude of 815-1000m above sea level. It is geographical located at 28.058221° N and 84.579862° E on the map. It is situated at the mid hill portion of Gandaki province. There are 7 VDC (Kerabara, Thalajung, Sabik Chhoprak, Harmi, Gakhu, Shrenathkot and Jaubari). Altogether, 19719 populations are present in Siranchwork rural municipality with 5958 families.¹⁴ The climate tropics, temperate and alpine is generally observed. According to the Department of Hydrology and Meteorology, the annual average temperature ranges from 19.35°C-10.09°C whereas the mean annual precipitation is recorded to be 254.87mm. Various ethnic people like Gurung, Brahmin, Chhetri, Sarki, Damai, etc are residing with higher number of hindu people. Shah, *et al.*,¹⁵ reported 80 plant species belonging to 72 genera from Gurung village of Siranchowk, Gorkha. The vegetation of the study area represents subtropical forest with dominant tree species *Schima, wallichii*, *Alnus nepalensis*, etc.; shrubs such as *Jatropha curcas*, *Colebrookea oppositifolia*, etc.; herbs such as *Cynodon dactylon*, *Acorus calamus*, etc. Gorkha district has sub-watershed of Marsyangdi River which provides the irrigation facilities to the land.

Mostly, four different land use types were identified from extensive visit in the study area (Table 1).

Table 1: Land use types and time since abandonment.

S.N.	Land use types	Land use history
1	Recently abandoned land (RA)	Abandoned for less than 5 years, dominated by herbs and sparse shrubs, without pasture pressure
2	Short-term abandoned land (SA)	Abandoned for 5-10 years, colonized with younger trees and shrubs, without pasture pressure
3	Long-term abandoned land (LA)	Abandoned for 15-20 years, colonized with more trees and shrubs, without pasture pressure
4	Reference forest (FO)	Regenerated 30 to 40 years after disturbance such as pasture, cutting and logging, litter removal, etc.

The history of agricultural land abandonment and forests was determined by interviewing residents with ethics approval.



Figure 1: Map of the study area

Sampling Design

A study with random sampling was conducted for the investigation of vegetation of different types of abandoned land and reference forest on Siranchowk, Gorkha. Initially, 20 random circular plots of radius 7m were made for each type of land and forest. The modified protocol of Sundryal and Sharma,¹⁶ was adopted for the sampling. Similarly, one circular plots of 3.5m radius for the shrubs and four circular plots of 1m radius for the herb species were established to determine the number of plant and their coverage. All the shrubs and herbs species present inside the quadrat were recorded. Altogether 120 sampling quadrats were made throughout the investigation. Also, soil samples were collected from the plot. The field data were used to calculate different diversity indices and evenness.

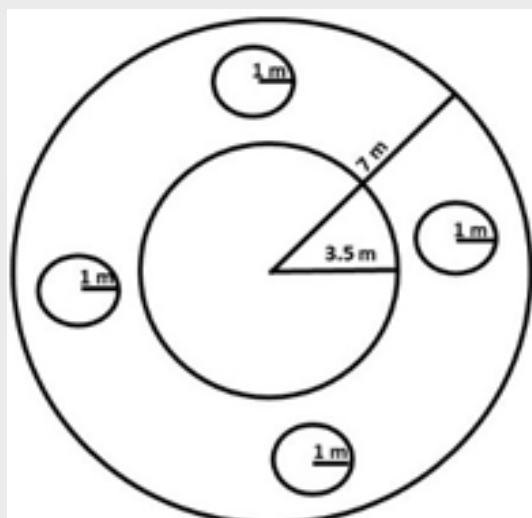


Figure 2: Scheme for sampling for trees, shrubs and herbs in different land use types.

Plant Species Collection

A comprehensive documentation was conducted on the field to prepare herbarium specimen of unique plant species which underwent meticulous procedure of herbarium making. Plant species were identified by the help of established literature sources, books and cross referencing with existing herbarium collection at ASCOL herbarium.

Soil Analysis

Soil samples were collected to gather relevant data on soil composition from topmost 10cm of soil depth. Subsequently, composite samples comprising a blend of all four-point samples per plot were created following Zobel *et al.*¹⁷ methodology. This systematic approach ensured that both plant specimens and soil compositions received thorough examination through careful methodologies tailored to achieve reliable results in this research endeavour.

Soil properties like soil pH, moisture content and humus content were analyzed from the collected soil samples. In order to determine the soil pH, a mixture of 50 gm of soil and 100 ml of distilled water was taken and a calibrated pH meter was used to measure the pH value of taken soil samples. Likewise, 10 gm of soil sample was kept in a crucible and was kept in an oven at 80°C for an hour. Then 5 ml hydrogen peroxide (H₂O₂) was added followed by oven drying. The protocol for soil analysis was followed as mentioned on Zobel, *et al.*, 1987.¹⁷

$$\text{Soil Humus content (\%)} = \frac{(b-a)-(c-a)}{(b-a)} \times 100\%$$

Where, a – weight of crucible set, b – weight of crucible set and soil, c - weight of the crucible set and soil after adding H₂O₂.

Data Analysis

Several indices, including species richness, diversity indices (Simpson's and Shannon-Wiener's), and Pielou's evenness, were used to assess the vegetative data. According to the concept of species richness, it is the total number of species found in a given area. Shannon-Wiener's Diversity Index¹⁸ was used to determine the

species diversity of the plant community. It is given by,

$$\text{Shannon-Wiener's Diversity Index (H)} = -\sum \left(\frac{n_i}{N} \right) \ln \left(\frac{n_i}{N} \right)$$

where N = Total number of individuals of all the species, and n_i = Total number of individuals of particular species.

Simpson Index of Diversity was calculated as suggested by Simpson.¹⁹

$$\text{Simpson Index of Diversity} = 1 - D; \text{ where, } D = \frac{\sum n(n-1)}{N(N-1)}$$

Pielou's Index measures the evenness of species within a community. It was calculated by the following formula.²⁰

$$\text{Evenness (e)} = \frac{H}{\ln S}$$

Where, H = Shannon-Wiener's Diversity Index, and S = Total number of species

The collected data from the study area were entered in Microsoft Excel 2016. Bar diagram were prepared in MS Excel 2016 while the multivariate analysis was done using statistical software R version 4.2.2.

RESULTS

Abandoned Agricultural Land and Vegetation Composition

Among the four different types of abandoned land, Long-term abandoned land (LA) showed higher Simpson Index value (0.83 ± 0.02) followed by Short-term abandoned land (SA), whereas recently abandoned Land (RA) showed lowest value (0.76 ± 0.03). Similarly, LA's Shannon index was higher with (1.93 ± 0.11) value than SA's and other categories, indicating a greater degree of

diversity in LA. Interestingly, as compared to other land use patterns, Reference Forest (FO) showed higher Pielou evenness; (0.91 ± 0.03). In addition, Long-term Abandoned land (LA) was found to have a higher observed richness of plant species; (8.8 ± 0.83) than both Short-term Abandoned land (SA) and other specified groups, indicating a more diversified and diverse flora in LA.

It was clear with the histogram that herbs were significantly more abundant in Recently Abandoned land (RA) than in other land use (Figure 3A) with Short-term Abandoned land (SA) trailing closely behind. The relative abundance of shrubs was higher in Long-term Abandoned land (LA) than in Reference Forest (FO). RA showed no any relative abundance of trees whereas FO showed maximum relative abundance of trees. Climbers were only discovered in RA, indicating that they were only present in the setting of newly deserted territory.

Similarly, from the histogram (Figure 3B) of relative abundance of vegetation at family level, Asteraceae was found to be of higher relative abundance in SA, Theaceae was maximum at SA as well as in FO than other family. Compositae had a higher average relative abundance in LA. In the investigated areas, Theaceae also showed a greater average relative abundance.

Artemisia vulgaris (Art.vul), *Ageratum conyzoides(Age.con)*, *Sapinadus mukorossi (Sap.muk)*, *Hypercium uralum(Hyp.ura)*, *Mimosa pudica(Mim.pud)*, were found maximum in RA which shows they prefer to grow in RA. *Bidens biternate (Bit.bid)*, *Caesalpinia decapitala (Cae.dec)*, *Bombax ceiba(Bom.cei)*, *Melastoma melabathricum(Mel.mel)* were found abundantly in both SA and FO, *Chromolaena odorata(Chr.odo)* *Blume balsamifera(Blu.bal)*, *Colebrookea oppositifolia(Col.opp)* plants were found abundantly in LA.

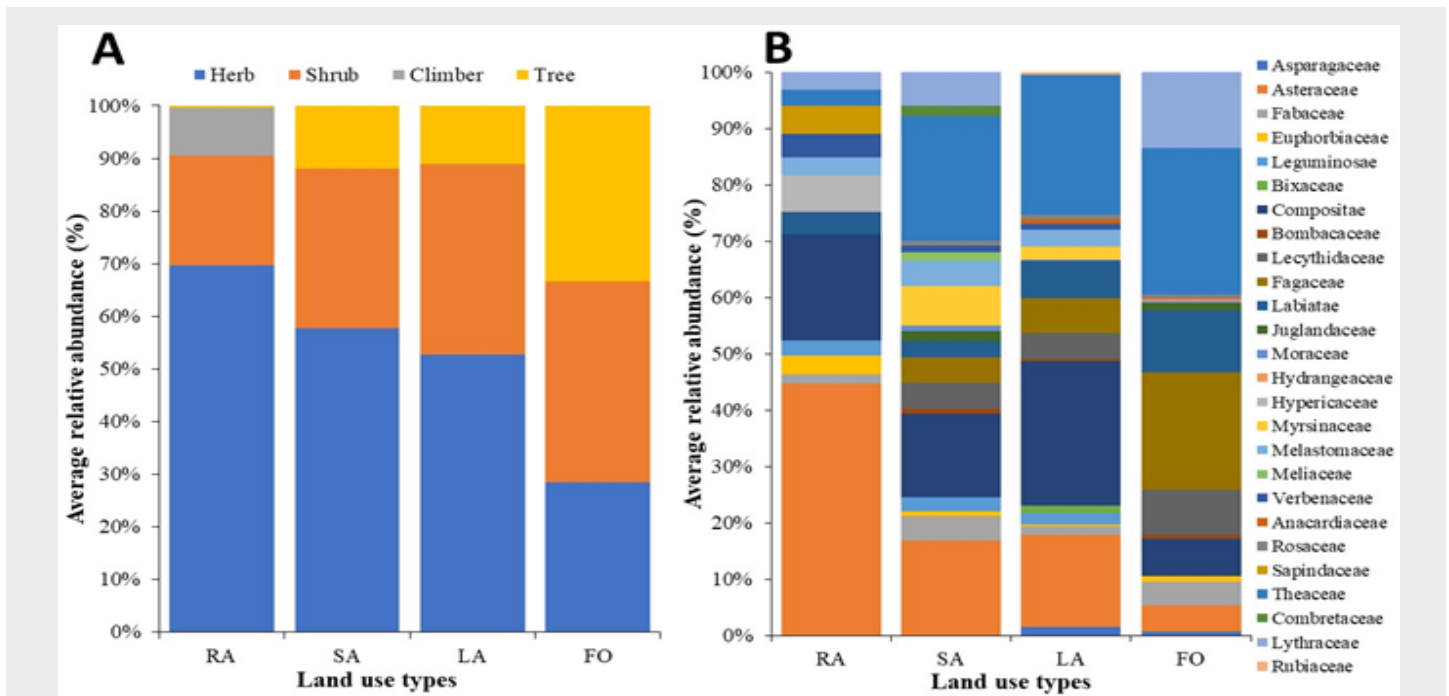


Figure 3: Relative abundance of vegetation (A, at life form level; B, at the family level) among land-use types. RA-recently abandoned, SA-short-term abandoned, LA-long-term abandoned FO-regenerated forest.

Table 2: Diversity indices of plant among land use types (Mean ± SD).

Land-use type	Simpson	Shannon	Pielou evenness	Observed richness
RA	0.76 ± 0.03 ^a	1.63 ± 0.11 ^a	0.84 ± 0.03 ^a	7.0 ± 0.70 ^a
SA	0.82 ± 0.01 ^b	1.88 ± 0.13 ^b	0.89 ± 0.03 ^b	8.4 ± 1.67 ^b
LA	0.83 ± 0.02 ^b	1.93 ± 0.11 ^b	0.88 ± 0.03 ^b	8.8 ± 0.83 ^b
FO	0.81 ± 0.03 ^b	1.78 0.20 ^c	0.91 ± 0.03 ^b	7.2 ± 1.48 ^a

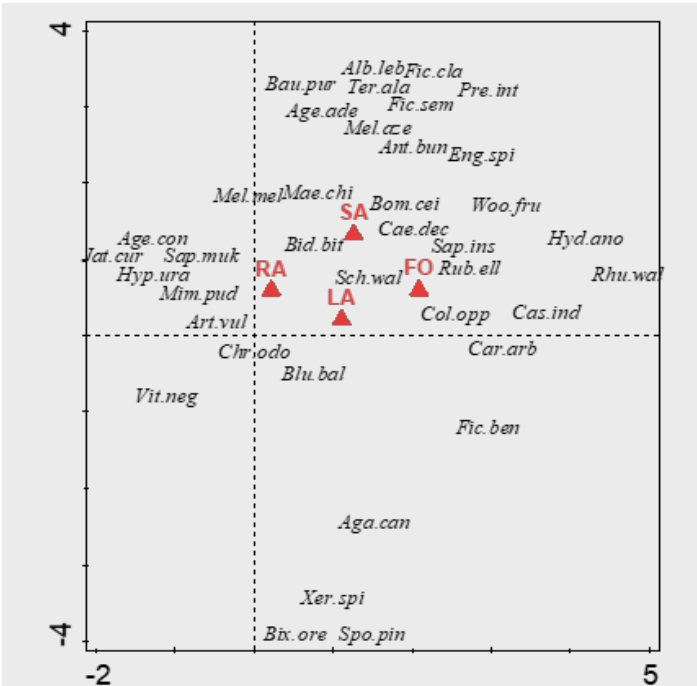


Figure 4: DCCA of vegetation among land use types (DCCA1=11.33%, DCCA2=3.32%). RA-recently abandoned, SA-short-term abandoned, LA-long-term abandoned, FO-regenerated forest. Land use type explain 23.1% variation in plant species composition which is significant (pseudo-F=1.6, p=0.002).

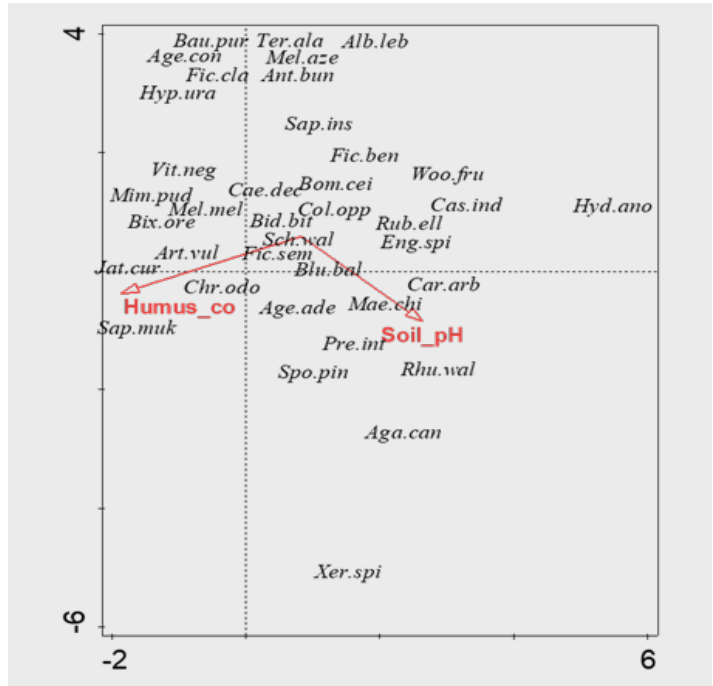


Figure 5: DCCA of vegetation with soil pH and humus content (DCCA1=9.2%, DCCA2=3%). RA-recently abandoned, SA-short-term abandoned, LA-long-term abandoned, FO-regenerated forest. Land use type explain 13.3% variation in plant species composition which is significant (pseudo-F=1.3, p=0.046).

Abandoned Agricultural Land and Soil Properties

The plants such as *Ageratum conyzoides* (*Age.con*), *Bauhinia purpurea* (*Bau.pur*), *Ficus clavate* (*Fic.cla*), *Hypericum uralum* (*Hyp.ura*) were negatively correlated with humus content which means these plants grows in no humus content area. The plants *Bidens biternata* (*Bid.bit*), *Colebrookea oppositifolia* (*Col.opp*), *Rubus ellipticus* (*Rub.ell*), *Engelbardia spicata* (*Eng.spi*), *Ficus bengalensis* (*Fic.ben*) *Bombax ceiba* (*Bom.cei*), *Schima wallichii* (*Sch.wal*), were positively correlated with humus content which shows they need lots of humus to complete their growth.

Plants *Ageratina adenophora* (*Age.ade*), *Maesa chisia* (*Mae.chi*), *Premna integrifolia* (*Pre.int*), *Rhus wallichii* (*Rhu.wal*), *Agave cantala* (*Aga.can*) were positively correlated with PH, which indicates ph. favors these plants in their growth. *Vitex negundo* (*Vit.neg*), *jatropha curpas* (*Jat.cur*), *Sapinadus mukorossi* (*Sap.muk*), *Artemisia vulgaris* (*Art.vul*), were negatively correlated with soil pH. *Ageratum conyzoides* (*Age.con*), *Bauhinia purpurea* (*Bau.pur*), *Ficus clavate* (*Fic.cla*), *Hypericum uralum* (*Hyp.ura*) were

negatively correlated with humus content which means these plants grows in no humus content area .

Based on the findings outlined in Table 3, it is evident that all examined land use types exhibit a slightly acidic soil pH, with recently abandoned agricultural land (RA) displaying a notably more acidic soil environment. In terms of humus content, both recently abandoned agricultural land (RA) and long-term abandoned agricultural land (LA) exhibited similar levels, followed sequentially by short-term abandoned agricultural land (SA) and reference forest (FO). Furthermore, the humus content (HC) was found to be highest in long-term abandoned agricultural land (LA), succeeded by recently abandoned agricultural land (RA) and short-term abandoned agricultural land (SA). In contrast, the reference natural forest (FO) demonstrated the lowest accumulation of humus content. These soil characteristics provide valuable insights into the environmental conditions associated with different land use types, emphasizing variations in soil acidity and humus accumulation.

Table 3: Soil properties in different land types.

Land-use Type	Humus Content (Mean±SD)	Soil pH (Mean±SD)
FO	0.468 ± 0.05 ^a	6.266 ± 0.45 ^a
LA	0.854 ± 0.04 ^b	6.458 ± 0.29 ^a
RA	0.824 ± 0.07 ^b	5.778 ± 0.29 ^b
SA	0.682 ± 0.05 ^c	6.356 ± 0.45 ^a

DISCUSSION

A comprehensive documentation of plant species within the study area yielded a total of 39 species across 24 families, with 3 classified as herbs, 1 as climbers, 15 as shrubs, and 20 as trees. Notably, the Shannon-Wiener index in the Reference Forest (FO) was determined to be 1.78 ± 0.20 , contrasting with observations by Muhammadi et al.²¹ in the Loveh forest of Iran. In various habitats, including forest, agricultural fields, riparian zones, human habitats, and wetlands, the Simpson diversity index exhibited values of 0.612, 0.789, 0.814, 0.736, and 0.633, respectively (Nepali & Singh, 2020). Consistent with these findings, the present study identified Simpson diversity indices of 0.76 ± 0.03 , 0.82 ± 0.01 , 0.83 ± 0.02 , and 0.81 ± 0.03 in Recently Abandoned (RA), Short-term Abandoned (SA), Long-term Abandoned (LA), and FO land use types, respectively. Pileous evenness in the current study revealed values of 0.84 ± 0.03 , 0.89 ± 0.03 , 0.88 ± 0.03 , and 0.91 ± 0.03 for RA, SA, LA, and FO, respectively, aligning with the work of Nepali & Singh (2020).

The investigation into the impact of abandoned agricultural land on soil properties focused on pH and humus content (HC). According to the results presented in Table 3, soil pH across all study sites ranged from 6.266 to 6.458, except in Recently Abandoned agricultural land, where it registered a weakly acidic pH of 5.778. The observed soil pH values in the study area did not exhibit significant variations, corroborating the findings of Raiesi (2011). Micronutrient availability for plant growth is known to be influenced by soil pH, with the optimum range for most crops falling between 6.0 and 7.5.²² In terms of humus content, Long-term Abandoned (LA) and Recently Abandoned (RA) lands exhibited similar levels, while Reference Forest (FO) showed comparatively lower humus content, deviating from other available literature.

The soil pH of the recent study of different types of abandoned farmland ranges from 5.7-6.7 which is similar to the work performed by Tian, et al.,²³ on Pakarbas, Ramechhap which showed that the soil was slightly acidic with pH 6.0-6.5 in farmlands. Similarly, Chauhan, et al.,²⁴ studied the soil chemical properties of land use system in Western Chitwan and recorded the pH ranging from 5.20-5.68 and illustrated that the soil is slightly acidic in nature which is found similar to the recent study. Likewise, Kharal, et al.,²⁵ also found the acidic soil in upland farms and lowland farms of Dhading district Nepal. The pH of agricultural land of Panchkhal, Kavre and Ambukhaireni, Tanahau was found to be 6.4, slightly acidic which firmly supports the present work.²⁶

Shah, et al.,¹⁵ reported 80 plants species belonging to 42 families used by Gurung community of Siranchowk, Gorkha for

different purposes which is found similar to the present works with documenting 39 plant species belonging to 24 families from the same area. Similarly, Manandhar²⁷ had recorded 100 species of plant belonging to 54 families from Gorkha district.

The investigation done by Pandey, et al.,²⁸ on two ecological regions of Central Nepal recorded 130 plant species on Argankhanchi and 99 plant species from Kaski with 1.24 and 1.21 Shannon-Weiner's diversity index as well as 0.091 and 0.087 Simpson's diversity index. The study enhanced that mid hills have similar plant diversity which supports the investigation made on Ripagaun, Gorkha. This was due to the familiar type of climate, soil types or other topographic factors. Also, a study conducted on rural areas of Dhulikhel municipality by documenting 136 plant species showed that Shannon-Weiner's diversity index of farm crops ranges from 3.13-4.078 and evenness ranges from 0.74-0.89 depending on the adaptable characteristics of crops on different land types.²⁹

CONCLUSION

The study found 39 plant species in a specific area, with a higher abundance of trees and fewer climbers. Long-term abandoned agricultural land (LA) had higher plant diversity than recently abandoned land (RA). Soil characteristics did not significantly impact agricultural abandonment, but humus content was slightly lower in LA compared to the natural forest (FO). This highlights the dynamic relationship between land-use changes and plant diversity, especially in abandoned agricultural lands. The findings provide insights into the ecological consequences of land-use transitions and the intricate relationships between vegetation and soil properties.

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CONFLICT OF INTEREST

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Annex 1

Plant Species found in Study Area

SN	Common name	Plant names	Abbreviation	Family	Habit
1	Ketuki	Agave cantala	Aga.can	Asparagaceae	Shrub
2	Banmasa kalo	Ageratina Adenophora	Age.ade	Asteraceae	Shrub
3	Gande	Ageratum conyzoides	Age.con	Compositae	Herb
4	Siris	Albizia lebbek	Alb.leb	Fabaceae	Tree
5	Archal	Antidesma bunius	Ant.bun	Euphorbiaceae	Tree
6	Titepati	Artemisia vulgaris	Art.vul	Asteraceae	Shrub
7	Tanki	Bauhinia purpurea	Bau.pur	Leguminosae	Tree
8	Kuro	Bidens biternata	Bid.bit	Asteraceae	Herb
9	Sidhure	Bixa orellana	Bix.ore	Bixaceae	Shrub
10	Gaitihare	Blume balsamifera	Blu.bal	Compositae	Shrub
11	Simal	Bombax ceiba	Bom.cei	Bombacaceae	Tree
12	Areli	Caesalpinia decapitala	Cae.dec	Leguminosae	Shrub
13	Kyamuno	Careya arborea	Car.arb	Lecythidaceae	Tree
14	Katus	Castanopsis indica	Cas.ind	Fagaceae	Tree
15	Banmasa seto	Chromolaena odorata	Chr.odo	Asteraceae	Shrub
16	Dhurseli	Colebrookea oppositifolia	Col.opp	Labiatae	Shrub
17	Mauwa	Engelhardia spicata	Eng.spi	Juglandaceae	Tree
18	Baar	Ficus bengalensis	Fic.ben	Moraceae	Tree
19	Gedule	Ficus clavate	Fic.cla	Moraceae	Tree
20	Peepal	Ficus religiosa	Fic.rel	Moraceae	Tree
21	Khadayo	Ficus semicordata	Fic.sem	Moraceae	Tree
22	Baunikath	Hydranga anomala	Hyd.ano	Hydrangeaceae	Tree
23	Khareto jhar	Hypericum uralum	Hyp.ura	Hypericaceae	Shrub
24	Sajjiwan	Jatropha curcas	Jat.cur	Euphorbiaceae	Shrub
25	Bilaune	Maesa chisia	Mae.chi	Myrsinaceae	Shrub
26	Angeri	Melastoma melabathricum	Mel.mel	Melastomaceae	Shrub
27	Bakaino	Melia azedarach	Mel.aze	Meliaceae	Tree
28	Nanijhar kada	Mimosa pudica	Mim.pud	Leguminosae	Herb
29	Gidari	Premna integrifolia	Pre.int	Verbanaceae	Tree
30	Bhalayo	Rhus wallichi	Rhu.wal	Anacardiaceae	Tree
31	Aaiselu	Rubus ellipticus	Rub.ell	Rosaceae	Shrub
32	Rithha	Sapinadus mukorossi	Sap.muk	Sapindaceae	Climber
33	Khirro	Sapium insigne	Sap.ins	Euphorbiaceae	Tree
34	Chilaune	Schima wallichii	Sch.wal	Theaceae	Tree
35	Amara	Spondias pinnata	Spo.pin	Anacardeceae	Tree
36	Saaj	Terminalia alata	Ter.ala	Combretaceae	Tree
37	Simali	Vitex negundo	Vit.neg	Verbenaceae	Shrub
38	Dhangeri	Woodfordia fruticosa	Woo.fru	Lythraceae	Shrub
39	Mainkada	Xeromphis spinosa	Xer.spi	Rubiaceae	Tree