Documentation of plant biodiversity and ethnobotany in Jhilmil area, Kanchanpur, Nepal

Man Dev Bhatt[1], Dirgha Raj Joshi[1], Gauri Shankar Bhandari[2], Sujan Maharjan[3], Dipesh Guragain[4], Pasang Tamang[4], and Ripu Mardhan Kunwar[5*]

Abstract

Documentation of the indigenous knowledge of plants plays a key role for the conservation and utilization of plant resources. The present paper documents the diversity of plants and their traditional use in and around the Jhilmil lake area, one of the forest-dominated peri-urban areas of Kanchanpur district. Fieldwork for vegetation sampling and ethnobotanical surveys was carried out twice between January 2020 and January 2021. Semi-structured questionnaire and checklist were used respectively to record the use and distribution of plant species and their conservation. A total of 126 plant species representing 52 families and 113 genera were reported. Among the total plants recorded, 114 (90.48 %) species were ethnomedicinally used. Results showed that the use of plants as ethnomedicine was culturally motivated and less influenced by availability of plants. Plant importance value index (IVI) was negatively associated with the plant relative frequency of citation (RFC) (p = 0.057 – 0.79). High RFC value of trees and climbers hinted that the plant collection is subjectively oriented for quality products. Rare plants (plants with less IVI) such as *Pterocarpus marsupium, Dalbergia latifolia, Rauvolfia serpentina, Citrus limon, Mussaenda frondosa,* etc. with high use values (high RFC) should be given priority for future conservation. It demonstrates that lake in forest areas is indeed a valuable resource for plant diversity and local livelihood, particularly because they contain high levels of local, rare and useful plant species.

Key words: Jhilmil lake, Importance Value Index, Ethnomedicine, Relative Frequency Citation, *Pterocarpus marsupium*

[1,2]Department of Botany Siddhanath Science Campus, Tribhuvan University, Nepal
[2]Resources Himalaya Foundation, Sanepa, Lalitpur
[3,]Basin Management Center, Gandaki, Pokhara, Nepal,
[4]Department of Forest and Soil Conservation, Ministry of Forests and Environment, Nepal
[5]Ethnobotanical Society of Nepal, Kathmandu, Nepal
[*] Corresponding Author: ripukunwar@gmail.com

Introduction

About 80% of the population of the developing world relies on traditional medicines for primary healthcare (WHO, 2014). In Nepal, about 70-80% of population in the mountain region depends on traditional medicines for health care (Manandhar, 1980). There are over 6,500 species of higher plants in Nepal of which about 2,000 species are used medicinally (Ghimire, 2008; Kunwar *et al.*, 2021). However, due to changing life style, secrecy of traditional healers, availability of modern health facilities and the tendency of younger generation to leave behind the tradional practices, the knowledge on medicinal plants is disappearing (Kutal *et al.*, 2021). The traditional knowledge of medicinal plants is declining fast in lowlands of Nepal (Manandhar and Chaudhary, 1988). Therefore, documentation of indigenous knowledge about the usefulness of plants from lowland areas is important for the preservation of traditional knowledge and conservation of useful plant species.

Wetlands, forests and flora of Lowland Tarai have increasingly decreased by area and density over the last few decades (Subedi, 2019), threatening the traditional livelihood. Tropical forests are confined to the Tarai and Siwalik, and comprise over 500 plant species (Shrestha *et al.*, 2002). There are over 240 wetland sites in western Nepal, of which 163 are in the lowland Tarai region of Nepal (Siwakoti & Karki, 2010). There are over 700 plant species including over 300 medicinal plants in Kanchanpur district and over 50% are being used in folklore medicine (DNPWC, 2006; Bhatt *et al.*, 2021). Khatiwada *et al.* (2019) reported 15 species of macrophytes from Jhilmil Lake, and Kunwar *et al.* (2015) inventoried the macrophytes of Mahakali river, which lies close to Jhilmil lake, and documented 140 plant species. Nepal's Tarai region is densely populated resulting in incalculable encroachment and pressure on forest resources. Forest encroachment, habitat degradation and biological invasion are prevalent in western Nepal (Weaver, 2001; Kunwar *et al.*, 2012), altering both the local flora and culture. Although indigenous and livelihood supporting, the collection of fuelwood, fodder, and edible and medicinal plants from the wild has created additional pressures in the forests and flora. The higher dependency on plants is due to the preferences given by local people to the subsistence livelihood and traditional herbal remedies, as well as poverty, accelerated human population, and belief in the effectiveness of folklore herbal remedies (Bhattarai, 1992). Escalating human onslaughts: habitat loss, agricultural run-off, drainage and over exploitation of resources base led to reduced area of wetlands thereby, endangering various biological resources. Moreover, the Tarai and wetland areas are on the hardest hit by the increasing temperature and erratic rainfall (DoFSC, 2021).

Rural remote areas enriched in biodiversity and managed by local communities for their livelihoods are often overlooked in research priority. Although the wetlands possess a number of values, services and products, the socio-economic factors, biodiversity and sustainability of wetlands have not been explored adequately (Poudel, 2009; Khatiwada *et al.,* 2021). Lake Jhilmil has high natural and religious significance. The lake is surrounded by dense forests, however, the status of plant biodiversity and utilization of plants and plant products is poorly understood. Documentation of plant biodiversity and indigenous knowledge through ethnobotanical studies play a crucial role in the conservation and sustainable utilization of plant biodiversity. The main objective of this study is to analyze the plant-people interactions in Jhilmil area, one of the forests dominated peri-urban areas of Kanchanpur district. To be precise, this study aims to document the composition of plant species, and assess the plant use values and conservation initiatives.

Study area and sites

Kanchanpur district is expanded from the northern ridge of Siwalik ranges to the southern boundary of lowland Tarai linked with India. The altitude of district ranges from 175 m south to 1575 m north and expanded from Mahakali River in west to Mohana River in the east. The recorded annual rainfall is 1717 mm and temperature ranges from 3^{o} to 42^{o} C and the climate is tropical to mid temperate (DDC, Kanchanpur, 2008). This district is gifted with a number of rivers, rivulets and gorgeous lakes like Betkot, Rani, Pyara, Sundue, Jhilmil, etc. However, the increasing temperature and erratic rainfall impacted the local biodiversity and livelihood much (Figure 1)

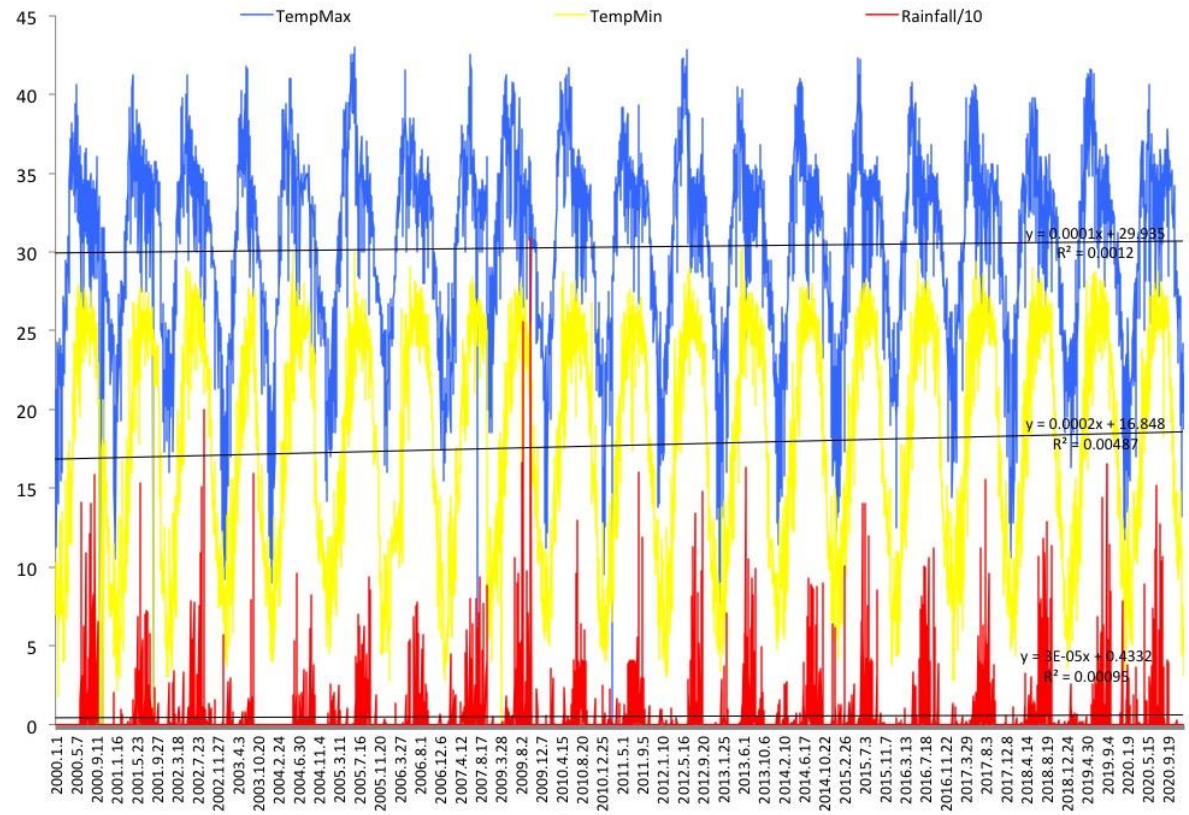


Figure 1. Daily temperature and rainfall of Mahendranagar (2000-2020)

Jhilmil lake, selected as a study site is the beautiful natural lake located at an altitude of 801 m at northern boundary of the district at ward no. 9, Bhimdatta municipality (DoF, 2017). It is 10 km far from the heart of Municipality. The lake covers roughly an area of about four hectares with dense forest surroundings. Southern and northern parts of the lake are slightly steep compared to eastern and western sides, and the lake is prone to landslide and litter deposition (Figure 2). Due to its natural beauty, surrounding evergreen forest, easy accessibility and the holy significance, approximately 3,000 visitors visit the lake annually mainly during Hindu festivals in Shrawan, Ashoj and Chaitra. Thus, the lake offers one of the major tourism growth potential in the district.

However, the lake is being gradually degraded by human interferences as a result of increasing tourists. Despite its touristic potential because of the natural beauty and holy pilgrimage significance, the lake was underappreciated. The ecological and ethnobotanical values of the lake have neither been documented nor evaluated in detail for socioeconomic and conservation impact.

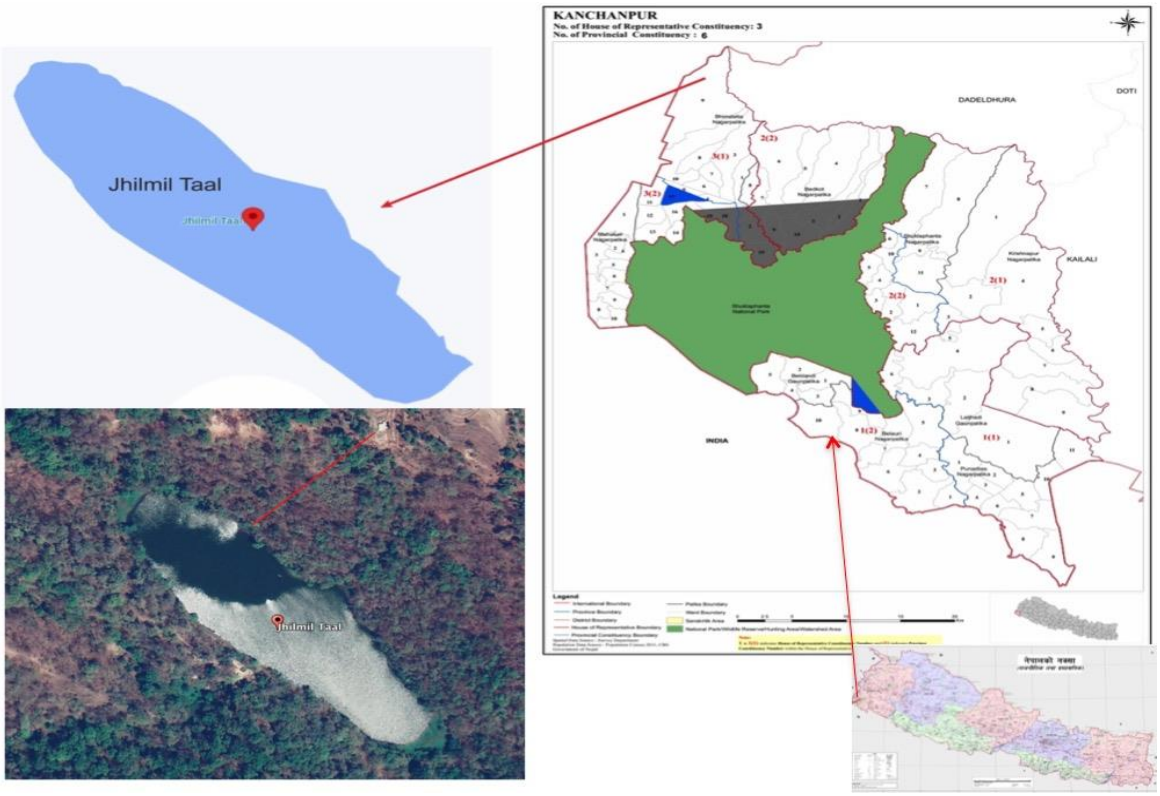


Figure 2: Location map of the study area (Jhilmil lake) with its Google Earth image (2021) (Source: DoFSC 2021)

Field visits and ecological and ethnobotanical study

Sampling was conducted around Jhilmil Lake covering all northern, southern, eastern and western sides. A total of 10 quadrats each measuring 10m×10m were laid following stratified random sampling following Misra (1968). Fieldwork was carried out twice between January 2020 and January 2021. Each fieldwork lasted for 25-30 days. The data and information regarding composition of plant species, habitat condition, indigenous uses of the plants, and local conservation measures were collected during fieldwork. Ecological indices such as distribution, frequency, density, and Importantance Value Index (IVI) were calculated following Curtis & McIntosh (1951) and Zobel *et al.*, (1987). Plant samples were collected for voucher records and for ethno-ecological assessments.

To assess the distribution of plant use knowledge, a total of 20 respondents including 15 men and 5 women, and age ranged between 45 and 75 years were randomly selected from Nyaule basti and Tarakot village lying at north and east sides of the Lake. Among the 20 respondents, 12 were vaidhyas (traditional practitioners of Ayurveda), two guruwas (ttraditional healers of Tharu community) and six were migrant traditional healers from

Darchula, Baitadi, Dadeldhura, Achham, Doti and Bajhang districts. The ethnic composition of the respondents was identified as Brahmin (2), Kshetri (3), Janajati (4), Dalit (5) and Tharu (6). They were interviewed using semi-structured questionnaire following Kunwar *et al.* (2019).

The name of useful plant species and its uses, along with the distribution, availability and mode of application were recorded while conducting survey. A semi-structured questionnaire was used for survey and supplementary information was collected through informal meetings (Putnam, 1975). While pursuing informal meeting and questionnaire surveys, information of vernacular names and dominant and most useful species as well as conservation of species was collected. The collected information was compared with the literature (Bhatt & Kunwar, 2020; 2021; Bhatt, 2019; Dhami, 2008; Kumar *et al.*, 2002). Furthermore, the species were reconfirmed by comparing with herbarium specimens deposited at Department of Botany, Siddhanath Science Campus, Mahendranagar. All voucher specimens (126) collected were deposited at Department of Botany, Siddhanath Science Campus, Mahendranagar. Scientific name of plants and their families were verified with referring to The Plant List (http://www.theplantlist.org/). Relative Frequency of Citation (RFC) was calculated by following formula Rehman *et al*. (2020). RFC= RC/N. In this formula, RC is the number of informants that uses species and the N represents the total number of informants in the survey. We considered $p < 0.05$ as statistically significant (Sokal & Rholf, 1995). We used generalized linear model regression to see whether the plant ecological value (IVI) and ethnomedicinal value (RFC) are correlated and higher plant use value is associated with higher ecological value.

Results

Jhilmil lake and ecosystems

Jhilmil lake is situated along the Churia range that links low lands Tarai and Bhimdutta municipality to the south and Mahabharat to the north. The northern and eastern part of the lake is wetland. Southern and western parts have mixed tropical vegetation of community forest. As it is located nearby Bhimdutta minuciupality, it is regarded as a periurban area. Peri-urban Jhilmil site is rich in forests, transition areas and abandoned land ecosystem. The lower belt of forested area of Jhilmil categorized under Baijnath Siddhanath community forest and upper area around Jhilmil Lake belongs to Churia Conservation Area (CCA) and protected by the rule and regulation of community forest act and CCA act of the government. Moreover, it has different land use and ecosystem types in its premises, however the land use

change resulted in increasing forest area by 1.37% at the expense of barren land (-1.35%) around the lake over a period of 10 years between 2010 and 2020.

Plant biodiversity

A total of 126 plants belonged to 52 families representing 113 genera were reported form the surrounding of Jhilmil Lake, Kanchanpur. With 19 species, Fabaceae was the dominant family, followed by Poaceae (7), Lamiaceae (7), Asteraceae (6), Apocyanaceae (5), Combretaceae (5), etc. (Table 1, Supplementary file 1). The southern and western sites of lake are rich in plant species richness and diversity as it has habitat mosaic habitat (open spaces, wetland ecosystem and undulating slopes) with gravel type soil texture.

Top 10 dominant plant species based on frequency, density and IVI are given in Table 1. As the forest is Sal (*Shorea robusta*) dominated, the species was profound in socio-ecological importance. Although the lake is located distantly from the city, the forests and settlements surrounding the lake were found invaded by Invasive Alien Plant Species (IAPS) such as *Ageratum houstonianum* and *Lantana camara*. The recorded dominant species were *Ageratum houstonianum, Cynodon dactylon, Himalayacalamus asper, Ocimum gratissimum, Rubus ellipticus, Asparagus racemosus, Eulaliopsis binata* and *Lantana camara* (Annex 1). Among the ten dominant species, one species was tree, three were shrubs, three were herbs, two were grasses, and one was climber.

Table 1: Dominant plant species reported around the Jhilmil lake

Species name	Local name	Family	Relative Density	Relative Frequency	IVI
Dioscorea deltoidea Wall. ex Griseb.	Tarul	Dioscoriaceae	2.90	0.88	1.89
Ocimum gratissimum L.	Ban Tulsi	Lamiaceae	2.40	0.88	1.64
Himalayacalamus asper Stapleton	Nigalo	Poaceae	2.29	0.88	1.58
Rubus ellipticus Sm.	Ainselu	Rosaceae	2.18	0.88	1.53
Cynodon dactylon (L.) Pers	Dubo	Poaceae	2.18	0.88	1.53
Ageratum houstonianum Mill.	Ganaune jhar	Asteraceae	2.12	0.88	1.50
Saccharum spontaneum L.	Kans	Poaceae	2.12	0.88	1.50
Shorea robusta Gaertn.	Saal	Dipterocarpaceae	1.95	0.88	1.42
Eulaliopsis binata (Retz.) C.E. Hubb	Babiyo	Poaceae	1.90	0.88	1.39
Lantana camara L.	Van Phandaa	Varbenaceae	1.84	0.88	1.36

As the study area is relatively less disturbed and distant from the human settlement, there are less number of shrubs and herbs and high number of trees (Table 2). There were 57 tree species, which accounted for 45% of the total (126) species.

Table 2: Top 10 plant species with the highest use citations and their IVI value

Scientific name	Local name	Family	Relative density	Relative frequency	IVI	Use RFC
Ocimum gratissimum L.	Ban Tulsi	Lamiaceae	2.40	0.88	1.64	0.9
Piper longum L	Pipla	Piperaceae	1.51	0.88	1.19	0.9
Artemisia vulgaris L. C.B. Clarke	Titepati	Asteraceae	1.00	0.88	0.94	0.9
Phyllanthus emblica L.	Amala	Phyllanthaceae	0.95	0.88	0.92	0.9
Tinospora sinensis (Lour.) Merrill	Gurjo	Menispermaceae	0.39	0.88	0.64	0.9
Ocimum tenuiflorum L.	Tulsi	Lamiaceae	0.33	0.59	0.46	0.9
Asparagus racemosus Willd.	Kurilo	Asparagaceae	1.78	0.88	1.33	0.85
Rauvolfia serpentina (L.) Benth ex Kurz	Sarpa ganda	Apocynaceae	0.73	0.88	0.80	0.85
Azadirachta indica A.Juss.	Neem	Meliaceae	0.33	0.88	0.61	0.85
Terminalia chebula Retz.	Harro	Combretaceae	0.22	0.59	0.41	0.85

Useful plants and their association with plant biodiversity

Among the 126 plant species found in study area, 114 (90.48 %) species were used to treat various ailments and diseases, and the other 12 (9.52 %) species were used as firewood, forage and fodder. The highest number of useful medicinal plants (> 90%) were attributed to the different use values of the lake, a mosaic settlement (a heterogenous society of migrant and native communities), and distant from the city core. The collection of forest products, fuelwood, fish, fodder and medicinal plants is rampant. The major trees of the lake are *Dalbergia sisoo, Adina cordifolia, Buchanania latifolia, Semecarpus anacardium, Terminalia tomentosa, Emblica officinalis, Bauhinia variegata, Alstonia scholaris, Bombax ceiba, Acacia catechu, Pterocarpus marsupium,* of them all are ethnomedicinal and the latter six are rare, indigenous and threatened.

We examined the relation of ecology and ethnomedicine by using the values of plants forms, IVI and families and use data (Figure 4). Neither Plant IVI nor Plant family IVI positively associates the plant collection and use. Both played negative association while the individual plant IVI and RFC were significantly negatively associated (p = 0.057, F= 3.66, R2 = 23). We did not find the values of ecology and ethnomedicine of a plant positively associated, i.e. plant folkmedicinal value (RFC) was negatively influenced by plant ecological value (IVI) (Figure 3).

Table 3. Ecological and ethnobotanical values across the plant life form

Plant life form	N	Average IVI	Average RFC	Remarks
Tree	57 (45.2%)	0.64	0.55	Dominant, Frequently used
Shrub	17 (13.4%)	0.92	0.41	
Herb	34 (27%)	0.85	0.51	
Grass	13 (10.3%)	1.06	0.27	
Climber	5 (4%)	1.12	0.62	
Total	126			

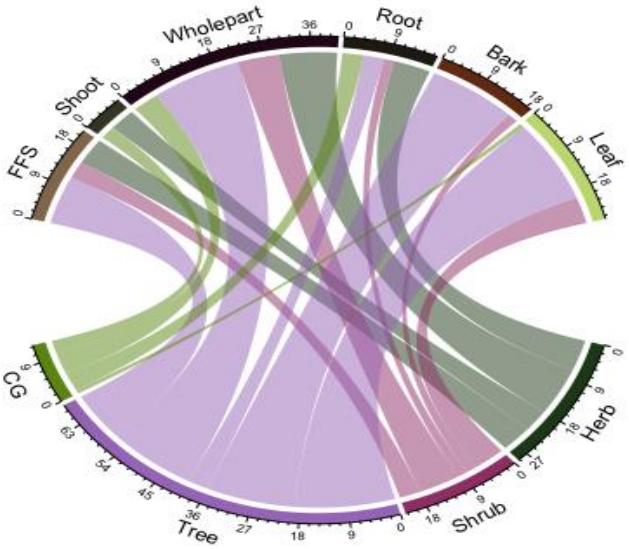
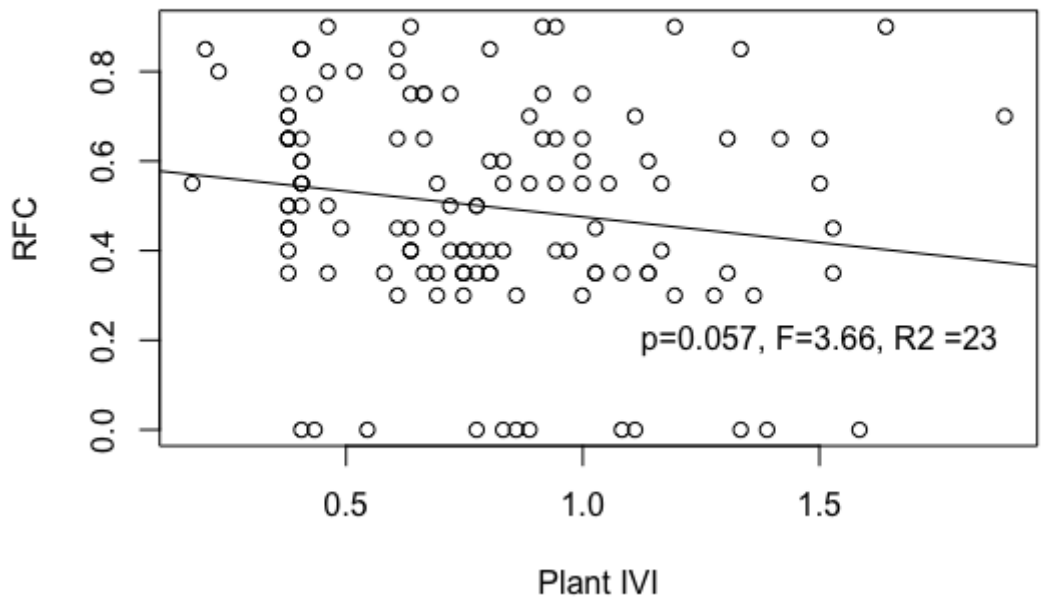


Figure 3: Chord-dendrogram showing plant parts and forms useful in ethnomedicine. CG = Climber and Grass



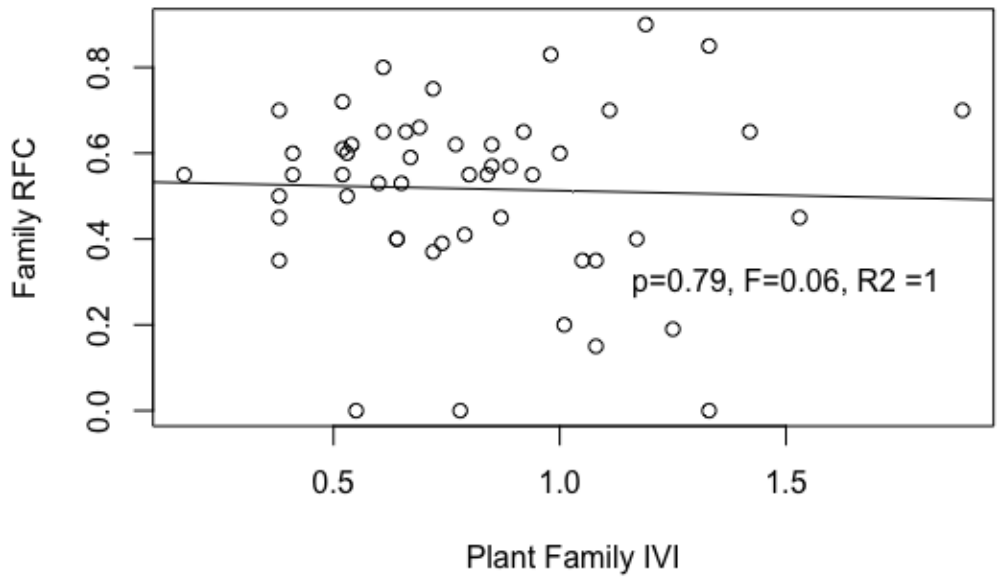


Figure 4a and b: Relationship of individual and family IVI and RFC values of plants

People of Jhilmil area, Kanchanpur district were found using the plants extensively. The use of plants ranged from food, fodder, wood, medicine, oil, fiber, aroma and ornamental value to religious. Despite the extensive uses of the plants for local livelihood, these resources have

underutilized and inadequately documented. There could be a large number of other species of socio-economic potential, urging the detailed and frequent inventories for better conservaiton.

Discussion

Jhilmil lake, situated along the Churia range that connects low lands Tarai to the south and relatively undisturbed and lush Mahabharat forests to the north is rich in plant biodiversity as it has surrounded by undisturbed forests, transition areas and abandoned lands. The lake plays important role in maintaining tree diversity as it has green forests in its surroundings. Southern and western parts have mixed tropical vegetation of community forest. As it is a peri-urban area where urban and rural activities are juxtaposed and ecosystems are subject to rapid modifications (Leaf, 2011), it has mixed species of both disturbed and undisturbed forests. Tree species being used in ethnomedicine and threatened as a result of overexploitations are *Alstonia scholaris, Bombax ceiba, Acacia catechu,* and *Pterocarpus marsupium* (Manandhar, 1990; Kunwar *et al.,* 2012). The hard wood hill Sal forest of the lake is gradually being succeeded to mixed type of forest (DFRS, 2015). The lake and its surroundings are being used as centers of fodder, fish, ecotourism, fuelwood, non-timber forest products, and irrigation and as a site for cultural tourism (Chalaune *et al.,* 2020). There are several natural water bodies around the lake, maintaining the soil moisture and biodiversity in its surroundings (Neupane *et al.*, 2011).

Anthropogenic landscapes and disturbed sites are rich in useful herbs and shrubs (Albuquerque & Lucena, 2005) and are frequently foraged (Kunwar, 2018) while the distant and primary forests are rich in trees. Out of 47 herbs reported by Gautam & Mandal (2016), 43 were found in disturbed forest and 30 in undisturbed forest. Fifty seven tree species were reported by Gautam & Mandal (2018) from the undisturbed tropical forest of eastern Nepal. There were only six invasive species reported from the study area *A. houstonianum, Chromolaena odorata, Lantana camara, Mimosa pudica, Imperata cylindrica* and *Parthenium hysterophorus* (Supplementary file 1). Among the IAPs, two *L. camara* and *A. houstonianum* were the dominant with IVI 1.36 and 1.50 respectively. Out of six, two (*L. camara* and *C. odorata*) are reported as the world's 100 worst invasive alien species (Lowe *et al*., 2000). A similar study carried out in tropical forest of Chitwan and Rautahat districts reported 11 IAPS (DoFSC, 2020).

Useful plants and their values

Out of 114 ethnomedicinal plants, the use reports for 61 species were matched with Dhami (2008) and 25 species with Singh (2014). The highest number of common useful species, 75 between Bhatt & Shakya (2015) and present study was attributed to the fact that both studies were carried out from the central part of Kanchanpur district. By family, Piperaceae (*Piper longum*), Asparagaceae (*Asparagus racemosus*) and Asteraceae were frequently cited for ethnomedicinal uses. There were three plant families (Linaceae, Orchidaceae and Selaginellaceae) and 12 species under-utilized for ethnomedicinal uses.

As evidenced from the Sah *et al.* (2003), the Jhilmil, Shuklaphanta, Kanchanpur area holds more than 560 plant species including over 200 useful species. A large number of useful plants are associated with the large number of plant species available (Charmakar *et al.*, 2021). It is plausible that human communities that inhabit ecosystems rich in species diversify their repertoire by using the large number of plant species (Salick *et al.*, 1999).

Of the reported 114 medicinal plant species, trees and leaves were frequently employed for ethnomedicine (Figure 3). Local people have been using different plant parts through various modes of application to cure different ailments such as dysentery, diarrhea, cough, inflammation, urinary diseases, jaundice, ulcer, asthma, diabetes, fever, cough, wounds and dermatological complaints (Supplementary table 1). Plant based therapies are persistent in western Nepal for primary and local health care (Dhami, 2008; Singh *et al*., 2012; Shakya, 2014; Bhatt & Shakya, 2015; Kunwar *et al*., 2016; Bhatt & Kunwar, 2020, Bhatt *et al.*, 2021). The ethnic people residing in different geographical belts of Nepal depend on wild plants to meet their basic requirements and all the ethnic communities have their own pool of secret ethnomedicinal and ethnopharmacological knowledge about the use of plants available in their surroundings, which has been serving rural people with its superiority (Panthi & Singh, 2013).

Association of ecology and ethnobotany

As inconsistent association shown between ecological and ethnomedicinal attributes, species cultural values, popularity and usefulness are supposed to be found related (Araujo *et al.*, 2008), meaning that the plant collection and use is less influenced by availability of plants and more dependent on cultural belief. Proximate and accessible areas are found be frequently visited for plant foraging (Kutal *et al.*, 2021). Thomas *et al.* (2009) showed that

the phytosociological indices are positively associated for non-medicinal use category (wood, fuel and construction uses) and less to the medicinal use categories. The result of our study hinted that the ecological values are useful for determining the general ethnobotanical practices whereas for ethnomedicinal collections, cultural belief and popularity take a lead. As individual plants and plant families had the negative association of their IVI and ethnobotanical values, the plant forms did not compose positive association, however insignificant (p = 0.71). The high RFC value of trees and climbers hinted that the plant collection is subjectively oriented for quality products, nor influenced by cost-benefit trade-offs (Thomas *et al.,* 2009). This shows that plant collection for ethnomedicine in Jhilmil Lake area was negatively influenced by plant IVI values. It is reasonable to assume that if the use pressure is directed to the species of less IVI, then the future availability of rare plants is jeopardized. Conservation of plants with the less IVI value and high RFC (such as *P. marsupium, D. latifolia, R. serpentina, Citrus limon, Mussaenda frondosa,* etc.) should be given high priority. These species were also found threatened because of their over exploitation for local livelihood and health care practices (Bhatt *et al.,* 2022).

Our results suggested that medicinal use values were not found influenced by the frequency and density, ecological values of plants in Jhilmil area, Kanchanpur. It seems apparent and obvious that the study area, enriched with culture and ethnomedicinal plants, is still influenced by local culture and tradition and being threatened by increasing pressure created by tourism.

Conclusions

Out of total 126 plant species reported, 114 (90.48 %) species were used ethnomedicinally in Jhilmil area, Kanchanpur. As the study area is relatively less disturbed and far from the city markets, there are less number of shrubs and herbs and high number of trees, among them climbers, trees and herbs were frequently used in folklore. However, the usage for ethnomedicine was culturally motivated as ecological variables negated the RFC value of plants (p = 0.057-0.79). Moreover the high RFC value of trees and climbers suggested that the plant collection is subjectively oriented for quality products. Ethnobotanical knowledge plays an important role in plant diversity conservation and the curing of various ailments in rural and remote areas. Rare plants (plants with less IVI) with current and potential high use values (high RFC) such as *P. marsupium, D. latifolia, R. serpentina, Citrus limon, Mussaenda frondosa* should be given high conservation priority.

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