Ethnomedicinal plants used by the local people of Changunarayan Municipality, Bhaktapur, Nepal

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Research

Abstract

Background: For centuries, the Changunarayan municipality has been inhabited by people who have a long tradition of using medicinal plants to treat human ailments. Habitat degradation and improper harvesting are the major threats to the medicinal plant species in this area. The present study aims at documenting and identifying plant-based ethnomedicinal knowledge of the local people in order to preserve the dwindling indigenous knowledge.

Methods: The primary information on the medicinal plants were collected through field observation, interviews, and a semi-structured questionnaire. A frequency index value was determined to compare the medicinal plants that were used frequently by the local people. Moreover, the factor of informant consensus (F_{IC}) was determined for the assessment of homogeneity on the informants' knowledge regarding medicinal plants. A Pearson correlation test and a simple linear regression were performed to evaluate the relationship between the age of respondents and plants described by them.

Results: A total of 96 medicinal plant species belonging to 56 families and 85 genera were used for the 40 different ailments documented in the municipality. Herbs (n = 47) occurred most frequently in the study area, and the most frequently used plant part was leaves (n = 30). The majority of the species were collected from the wild (57%). *Ocimum tenuiflorum* and *Curcuma longa* had the highest frequency index of 65%. The value of Chi-square test between genders and the number of plants described by them was determined to be significant (p-value < 0.001). A positive correlation (r = 0.708) was found between the age groups of informants and the number of plants described by them. The F_{IC} value in the study ranged from 0.4 (cardio-vascular) to 0.90 (fever).

Conclusion: The medicinal plants have been playing an enormous role in the health care of the villagers, though the study area is very close to the capital city. The plants used in the study might open the way for the development of a scientifically verified botanical derivatives for modern medicine. Valuable traditional knowledge was limited to the older generation, which indicates a huge gap in knowledge transmission from the older to the younger generation.

Keywords: Ailments, Local interventions, Threats, Traditional knowledge

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Background

Ethnobotany includes ethnomedicine, which is a collection of empirical local practices rooted in local and indigenous knowledge systems (Bussmann & Sharon 2006). It is frequently passed down orally from generation to generation with the goal of understanding the social, cultural, and economic variables that influence health problems and overcoming them (Kunwar & Bussmann 2008). Ethnomedicinal studies are important source of information for discovering novel compounds that can lead to drug discovery (Umair *et al.* 2017). In fact, the systematic documentation of traditional knowledge on utilization of native plant species has contributed to a number of vital drugs (Cox 2000, Umair *et al.* 2017). Documenting traditional knowledge and practices is also crucial for establishing medicinal plant management and conservation programs (Njoroge *et al.* 2004). Plant resources are still being used in many regions of Nepal to fulfill subsistence requirements or to market as edible fruits, vegetables, fodder, medicinal herbs, and raw materials for home construction and domestic products, according to a large number of ethnobotanical studies published in Nepal (Manandhar 1989, Bhattarai *et al.* 2006, Rokaya *et al.* 2010, Uprety *et al.* 2010, Bhattarai 2018, Kunwar *et al.* 2018, Pradhan *et al.* 2020, Chaudhary *et al.* 2020, Mallik *et al.* 2020, Khakurel *et al.* 2021).

Nepal is rich in biodiversity because of sharp physiographic and climatic variations. The country is enthralled by 13,067 plant species, including 6973 angiosperms (Groombridge & Jenkins 2002). Some 125 ethnic groups are inhabited in the country (CBS 2011). These groups are highly dependent on biological resources and also contribute to their conservation and management, resulting into rich biocultural diversity. Nepal has a strong cultural foundation in traditional medicine and may be found in a variety of forms, including ethnic or tribal groupings, rituals or ceremonial acts, spiritual practices, diets, or self-healing methods (Koirala & Khaniya 2009). Medicinal plants play a vital role in Nepalese livelihoods. Only 15-20% of Nepal's population living in and around cities has access to modern medical services, while the remainder relies on traditional remedies (Sharma *et al.* 2004). Plants and plant products have augmented human culture since time immemorial (Chaudhary *et al.* 2020). In Nepal, there are about 8.4 million indigenous people of different groups inhabiting various terrains. They possess their own culture, religious rites, and rich traditional medicinal practices (Rokaya *et al.* 2010). For centuries, indigenous peoples and local communities have been using traditional knowledge under local laws, customs, and traditions to cure different diseases. Indigenous knowledge not only identifies local resources, but also offers a management framework for them (Koirala & Khaniya 2009).

Deforestation and human encroachment are fast leading to agricultural land and urbanization in the former jungle, posing a significant danger to the usage of medicinal plants, their products, and local traditional practices (Gachhadar 2006) which can be related to Changunarayan Municipality, Bhaktapur, Nepal. Furthermore, because allopathic drugs are readily available, they have supplanted traditional medical methods (Thorsen & Pouliot 2016). However, as medicinal plants and its accompanying traditional knowledge become more popular, the number of people and national and international institutions seeking information on them is fast growing (Gachhadar 2006). Due to a lack of documentation and a change in lifestyle, traditional medicinal practice is on the danger of extinction on a local and regional level (Rajbanshi & Thapa 2019). Furthermore, researchers from Africa (Cock & Van Vuuren 2020), Europe (Musarella *et al.* 2019), United States (Bennett & Prance 2000), Oceania (Shewamene *et al.* 2020), and Asia (Singh *et al.* 2021) have also recorded the loss of traditional medical knowledge. The present study documented the medicinal plants used by the people of Changunarayan municipality for the treatment of different human ailments as well as livestock, and also the method of using the medicinal plants for the treatment of disease.

Materials and Methods

Study area

The study was conducted in the Changunarayan municipality of Bhaktapur district, which is located in the Bagmati Province, Central Nepal (Figure 1). The Changunarayan municipality is located in the northern part of Bhaktapur and is 18 km away from the capital city (Kathmandu) of Nepal. It got its name from the very famous temple, Changunarayan, which is listed as a World Heritage Site. The municipality covers an elevational range of 1372 m to 2191 m above sea level (asl) with a geographical area of 62.98 km^2. The average annual temperature and rainfall in Bhaktapur is 19.07˚C and 1140.3 mm respectively (GoN 2019). The municipality includes 9 wards within it. The Changunarayan municipality had a population of 88612, of which 44073 were men and 44539 were women (CBS 2021). The major ethnic groups are Brahmin, Chhetri, and Newar, and the major religions are Hindu, Buddhist, Christian, and Muslims.

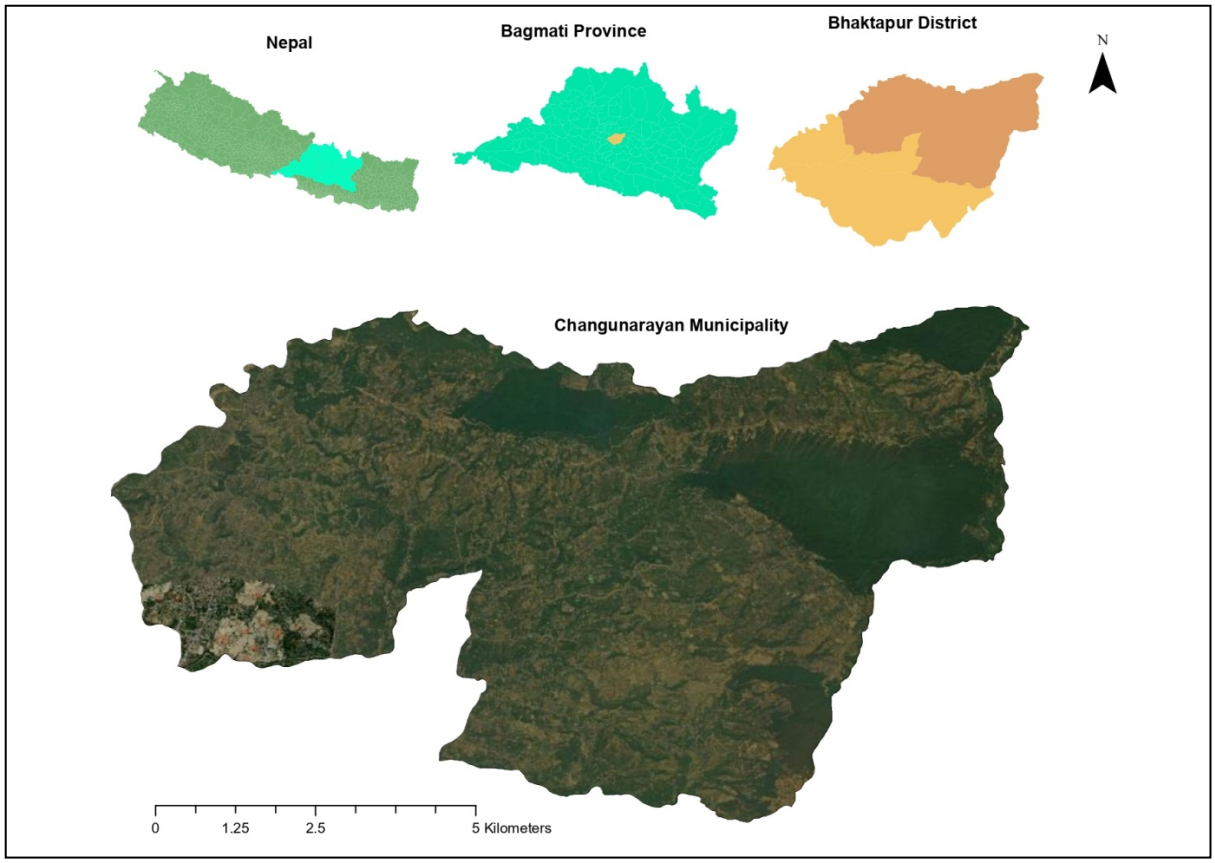

Figure 1. Map of the study area.

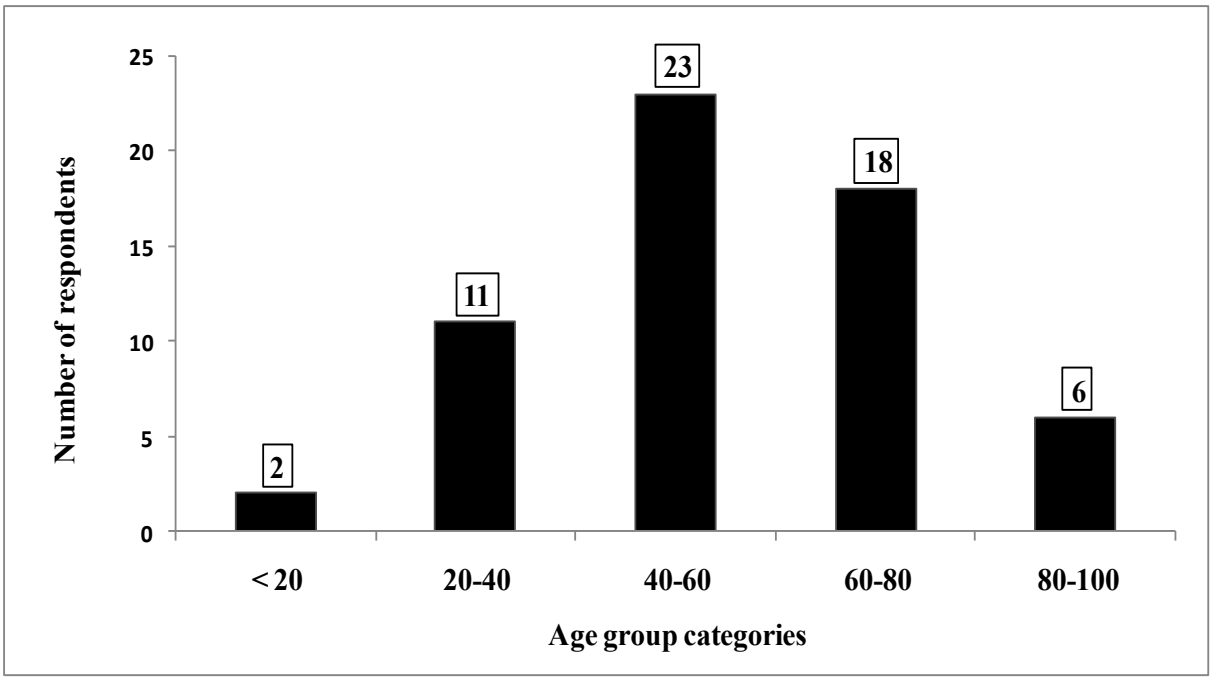

Figure 2. The number of respondents under five age group categories

Demographic data and primary data collection

The ethnomedicinal survey involved a total of 60 informants from the municipality. Among the 60 respondents, 27 were women and 33 were men. In the age group category, 6 respondents were between 80 and 100, 18 between 60 and 80, 23 between 40 and 60, 11 between 20 and 40, and 2 respondents below 20 (Figure 2). In the present study, the respondents below 40, between 40 and 60 and above 60 years old were referred as young age, middle

age and old age respectively. However, the respondents below 20 years of age were regarded as young teenagers. A simple random sampling method was used to select representative general informants. Moreover, eight key informants were selected following the purposive sampling described by Tongco (2007) because of their experience and knowledge regarding medicinal plants. Key respondents were farmers, *Pujaris, Dhamis* and *Shamans* of the local area. In Nepal, *Pujaris* and *Dhamis* are people who have a belief in God and ghosts and are supposed to treat health ailments and bad spirits with their holy power. They mostly use different types of plants in this process, which may sometimes not be used. Young teenagers (below 20) were also selected in the present study to reduce biasness and know about the knowledge gap and transfer of knowledge regarding medicinal plants from the older generation to the younger one. The informant's ages ranged from 16-94. The purpose of the study was initially described to all the respondents before the collection of data. Verbal consent was obtained from all the respondents to document and publication of their knowledge.

The ethnomedicinal data was collected in the months of April and June 2019. During preliminary data collection, ethnomedicinal data was collected from informants using semi-structured and open-ended questionnaires. Primary data was collected by going door to door and being face-to-face with local researchers and local experts. The questionnaires were prepared in English, but the interviews were conducted in local languages for convenience and accuracy. The present study has followed the code of ethics, principle and guidelines set by International Society of Ethnobiology (2006).

Plant collection, identification and herbarium preparation

The plant species were collected with the help of respondents. A list of medicinal plants with their local names was noted and photographs were taken initially. Identification of the plants were done by taking help from local knowledgeable people and comparing available local names with the documented names and photographs (if available) published/mentioned in various books and other literature (Shrestha 1998, Joshi & Joshi 2006, DPR 2016). However, most of the identification was done with the help of the experts. Nomenclature followed the catalogue of life (https://www.catalogueoflife.org/col/search/).The collected plant specimens were dried and pressed. The herbarium specimens were prepared according to Lawrence (1951). Accession codes (CHG) were given to the herbarium specimens and were submitted to the Bhaktpaur Multiple Campus herbarium of Bhaktapur Multiple Campus, Nepal.

Data analysis

The information collected through field visits was compiled, categorized and analyzed into local names of the plants, family, life form, parts used, plant habitat and medicinal use of the plants in the excel sheet. More than 180 research articles (2000-2022 AD) were reviewed from Google scholar, Research4life, Researchgate and Pubmed for the citation of similar use reports from Nepal in Table 1. Moreover, ethnomedicinal review article of each species was also considered for citation of similar use reports from Nepal. Descriptive analysis (pie chart, bar graph, and tables) was performed in MS Excel 2007. Normality of data was tested with Shapiro-Wilk test for Pearson Correlation test. A simple linear regression and Pearson correlation test was performed to observe the relationship between respondents and number of plants described by them. Moreover, a chi-square test for independence was carried out to test for a significant difference between the genders and the number of plants described by them. All these statistical analyses were performed in R version 4.0.3. A frequency index was also calculated for the quantitative analysis. The frequency index is the mathematical expression of the percentage frequency of mentions of a single botanical species by informants (Mahwasane *et al.* 2013). The following formula was used to calculate the frequency index:

$$FI = \frac{FC \times 100}{N}$$

Where FC is the number of informants who mentioned the use of the species and N is the total number of informants (Madikizela *et al.* 2012).

Table 1. List of medicinal plants used by the local people of Changunarayan municipality with family, local name, life form, parts used, habitat and medicinal uses

Family	Scientific name	Voucher number	Species collected from an altitude (m)	Local name	Habit	FI value	Parts used	Habitat	Medicinal use	Similar use reports
Acanthaceae	*Justicia adhatoda* L.	CHG 52	1745	**Asuro**	S	5	Leaf	C	Leaf boil in water with Tulsi and taken for fever	Tamang *et al.* 2017; Gubhaju & Gaha 2019
Acoraceae	*Acorus calamus* L.	CHG 7	1555	**Bojho**	H	52.5	Rhizome	C	Rhizome eaten for sore throat, neck problem, cough	Acharya & Pokhrel 2006; Tamang *et al.* 2017; Adhikari *et al.* 2019; Gubhaju & Gaha 2019; Thapa 2020; Poudel *et al.* 2021
Amaranthaceae	*Achyranthes aspera* L.	CHG11	1547	**Datiwan**	H	25	Root	W	Root juice taken for fever and help in easy fall of placenta in delivered women	Magar *et al.* 2022
Amaranthaceae	*Amaranthus spinosus* L.	CHG 63	1478	**Ludey**	S	47.5	Seed	C	Seed grinded and paste used in itching (skin problems)	Joshi & Joshi 2000
Amaryllidaceae	*Allium sativum* L.	CHG 64	1589	**Lasun**	H	32.5	Whole plant	C	Bulb used for gastric, constipation	Ndukwu & Ben-Nwadibia 2005; Tamang *et al.* 2017; Adhikari *et al.* 2019; Gubhaju & Gaha 2019
Anacardiaceae	*Semecarpus anacardium* L.	CHG 81	1678	**Bhalayo**	T	2.5	Fruit	W	Fruit used as anthelminthic, fever	Not found
Apiaceae	*Centella asiatica* L.	CHG 61	1443	**Ghodtapre**	H	52.5	Leaf, root	W	Used as cooling tonic, urine purifier,	Acharya & Pokhrel 2006; Bhattarai 2017; Tamang *et al.* 2017; Gubhaju & Gaha 2019;

									fever, memory booster	Bhatt & Kunwar 2020; Poudel *et al.* 2021
Apiaceae	*Coriandrum sativum* L.	CHG 89	1536	**Dhaniya**	H	7.5	Aerial part	C	Maintain proper digestion	Platel & Srinivasan 2004
Araceae	*Colocasia esculenta* L.	CHG 44	1650	**Karkalo**	H	5	Latex	C	Latex used in swollen body part	Not found
Asparagaceae	*Agave americana* L.	CHG 12	1714	**Kettuke**	S	10	Leaf	W	Leaf juice used for constipation	Ojha Khatri *et al.* 2021
Asparagaceae	*Asparagus racemosus* Willd.	CHG 2	1690	**Kurilo**	S	12.5	Tender shoot, root	C	Nerve disease, reduce body pain, root powder increase lactation	Rai & Singh 2015; Bhattarai 2017; Tamang *et al.* 2017; Thapa 2020
Asphodelaceae	*Aloe vera* L.	CHG 3	1515	**Ghiukumari**	H	47.5	Leaf	C	Gel used in burnt, wounds, regulation of menstruation, constipation	Bhattarai 2017; Tamang *et al.* 2017; Adhikari *et al.* 2019; Gubhaju & Gaha 2019; Thapa 2020; Miya *et al.* 2021
Asteraceae	*Ageratina adenophora* (Spreng.) R. King & H. Rob.	CHG 6	1565	**Banmara**	S	42.5	Leaf	W	Leaf juice used to stop bleeding in cuts	Tamang *et al.* 2017; Shah & Lamichhane 2017; Adhikari *et al.* 2019; Gubhaju & Gaha 2019; Budha-Magar *et al.* 2020
Asteraceae	*Artemisia vulgaris* L.	CHG 62	1551	**Titepati**	H	57.5	Leaf	W	Leaf paste used on cuts to stop bleeding, gastric, decrease pressure and sugar, anthelminthic, typhoid	Nadeem *et al.* 2013; Shrestha *et al.* 2016; Tamang *et al.* 2017; Hussain 2020

Asteraceae	*Cirsium wallichi* DC.	CHG 90	1554	**Thakailo**	H	15	Root	W	Root given to delivered women for energy, treat fever	Poudel *et al.* 2021; Gautam & Timilsina 2022
Asteraceae	*Smallanthus sonchifolius* (Poepp. & Endl.) H.Rob.	CHG 67	1665	**Bhuisyau**	H	5	Tuber	C	Control diabetes	Ojha Khatri *et al.*2021; Bhaila *et al.*2022
Asteraceae	*Sonchus oleraceus* L.	CHG 72	1536	**Kandpate**	H	2.5	Root	W	Root paste applied for earache, leaf latex used for cuts and wounds	Not found
Asteraceae	*Tagetes erecta* L.	CHG 38	1558	**Sayapatri**	H	5	Flower	C	Appetite loss, pneumonia	Bhaila *et al.*2022
Berberidaceae	*Berberis aristata* DC.	CHG 9	1459	**Chutro**	S	10	Stem	W	Paste used in skin problems, eye boils (aankha pakeko),	Shah & Lamichhane 2017; Gautam & Timilsina 2022
Berberidaceae	*Berberis napaulensis* (DC.) Spreng	CHG 92	1510	**Jamaino mandro**	S	5	Bark	W	Bark paste applied in eye inflammation, eye problems	Manandhar 2002; Baral & Kurmi 2006; Shrestha *et al.* 2014
Bignoniaceae	*Oroxylum indicum* L.	CHG 23	1745	**Tatelo**	T	10	Seed	C	Used to treat blood in stool (ragatmasi), appetite	Miya *et al.* 2021; Bhaila *et al.* 2022
Boraginaceae	*Rochelia zeylanica* Vahl.	CHG 57	1578	**Kanike kuro**	H	27.5	Root	W	Root paste taken for diarrhoea (aaupareko)	Not found
Brassicaceae	*Nasturtium officinale* R.Br.	CHG27	1885	**Simsag**	H	5	Aerial part	W	Control sugar and pressure level	Not found

Campanulaceae	*Lobelia pyramidalis* Wall.	CHG 83	1678	**Eklebir**	H	2.5	Bark	W	Increase fertility	Bhaila *et al.* 2022
Cannabaceae	*Cannabis sativa* L.	CHG 60	1546	**Ganja**	H	20	Seeds	W	Seeds given to livestock to cure dysentery, relief pain	Dhami 2008; Gautam & Timilsina 2022
Caryophyllaceae	*Drymaria cordata* L.	CHG 15	1493	**Abijalo**	H	5	Leaf	W	Leaf juice taken during indigestion, appetizer	Bhaila *et al.* 2022; Gautam & Timilsina 2022
Combretaceae	*Terminalia chebula* Retz.	CHG 74	1406	**Harro**	T	15	Seed, bark	W	Burnt seed (prepared in flame of fire)are taken for cough, bark chewed in urinary problems	Tamang *et al.*2017; Gautam & Timilsina 2022
Convolvulaceae	*Cuscuta reflexa* Roxb.	CHG 87	1391	**Akasbeli**	H	50	Whole plant	W	Whole plant used for jaundice	Bhattarai 2017; Tamang *et al.* 2017; Adhikari *et al.* 2019; Gubhaju & Gaha 2019; Thapa 2020; Poudel *et al.* 2021
Crassulaceae	*Bryophyllum* sp.	CHG 13	1611	**Ghiu pate**	H	5	Leaves	C	Leaf paste used in ear problems	Not found
Cucurbitaceae	*Cucumis sativus* L.	CHG 58	1502	**Kakro**	Cl	12.5	Fruit	C	Stone problem, act as cooling tonic of the body	Bhaila *et al.* 2022
Cucurbitaceae	*Momordica charantia* L.	CHG 37	1546	**Tite karela**	Cl	20	Fruit	C	Control pressure and sugar level,	Adhikari *et al.* 2019; Gubhaju & Gaha 2019; Pradhan *et al.* 2020; Poudel *et al.* 2021
Cyperaceae	*Cyperus rotundus* L.	CHG 47	1480	**Mothe**	H	12.5	Stem, leaves	W	Anthelminthic for livestock	Adhikari *et al.* 2019
Dioscoreaceae	*Dioscorea deltoidea* Wall.	CHG 16	1545	**Bhyakur**	H	7.5	Rhizome	W	Boiled rhizome taken in	Miya *et al.* 2021

									abdominal pain	
Dioscoreaceae	*Dioscorea alata* L.	CHG 49	1654	**Tarul**	Cl	55	Rhizome	C	Rhizome eaten for throat pain	Not found
Ericaceae	*Gaultheria fragrantissima* Wall.	CHG 54	1580	**Dhasingare**	S	10	Young shoot	W	Juice used as antiseptic, injury	Bhaila *et al.* 2022
Ericaceae	*Lyonia ovalifolia* Wall.	CHG 51	1556	**Angeri**	T	5	Leaves	W	Leaf paste applied on body for few minutes and the bath to reduce itching problems	Shah & Lamichhane 2017; Tamang *et al.* 2017; Adhikari *et al.* 2019; Gautam & Timilsina 2022
Ericaceae	*Rhododendron arboreum* Sm.	CHG 80	1880	**Laligurans**	T	50	Flower	W	Heck stuck, stone problem, clear voice	Adhikari *et al.*2019; Budha-Magar *et al.*2020
Euphorbiaceae	*Euphorbia royleana* Boiss.	CHG 46	1470	**Siudi**	H	20	Leaf	W	Fever, stop bleeding, appetite	Bhaila *et al.* 2022
Fabaceae	*Bauhinia variegata* L.	CHG 1	1548	**Koiralo**	T	7.5	Bark	W	Bark used for body ache, indigestion	Pradhan *et al.* 2020; Bhaila *et al.* 2022
Fabaceae	*Lablab purpureus* L.	CHG 48	1546	**Tate simi**	Cl	5	Leaf	C	Leaf juice used in skin scars, allergy	Not found
Fabaceae	*Macrotyloma uniflorum* Lam.	CHG 21	1554	**Gahat**	H	15	Aerial part	C	Used to treat chicken pox, stone problem	Tamang *et al.* 2017
Iridaceae	*Gladiolus* spp.	CHG 85	1457	**Tarbare phool**	H	37.5	Root	C	Root juice used for indigestion and appetite	Not found
Juglandaceae	*Juglans regia* L.	CHG 19	1685	**Okhar**	T	10	Leaf	C	Anthelminthic, tooth problems	Tamang *et al.* 2017; Budha-Magar *et al.* 2020
Lamiaceae	*Mentha arvensis* L.	CHG 93	1523	**Babari**	H	20	Aerial part	W	Fever, headache	Bhaila *et al.* 2022

Lamiaceae	*Mentha piperita* L.	CHG 82	1578	**Vicks**	H	15	Young leaves	C	Cough, sore throat, common cold	Shah & Mello 2004
Lamiaceae	*Ocimum tenuiflorum* L.	CHG 35	1550	**Tulsi**	H	65	Leaf	C	Leaf boil in water and taken for fever, cough	Tamang *et al.* 2017; Poudel *et al.* 2021
Lamiaceae	*Vitex negundo* L.	CHG73	1590	**Simali**	S	5	Leaf, bark	W	Sinusitis	Tamang *et al.*2017; Bhaila *et al.*2022
Lauraceae	*Cinnamomum tamala* Buch.-Ham	CHG 42	1449	**Tejpat**	T	17.5	Bark, leaf	W	Fever, cough	Adhikari *et al.* 2019; Bhaila *et al.* 2022; Gautam & Timilsina 2022
Lauraceae	*Persea americana* Mill.	CHG 32	1548	**Avocado**	T	25	Fruit	C	Lower the cholesterol level	Not found
Malvaceae	*Hibiscus rosa-sinensis* L.	CHG 53	1524	**Ghanti phool**	S	15	Flower	C	Flower act as urine purifier	Pradhan *et al.* 2020
Meliaceae	*Azadirachta indica* A. Juss.	CHG 10	1597	**Neem**	T	52.5	Leaf, bark	C	Leaf juice for fever, for control of sugar level, high blood pressure	Bhattarai 2017; Thapa 2020; Gautam & Timilsina 2022
Meliaceae	*Melia azedarach* L.	CHG 20	1519	**Bakaino**	T	50	Seed	W	Seed taken as anthelminthic, antidandruff function	Thapa 2020
Menispermaceae	*Cissampelos arenicola* M.Nee and R.Ortiz	CHG 59	1693	**Batulpate**	H	15	Aerial part	W	Stop bleeding in delivered women, also livestock	Bhaila *et al.* 2022
Menispermaceae	*Tinospora sinensis* Lour.	CHG 71	1547	**Gujro gano**	Cl	20	Root	W	Root juice maintain appetite, reduce body ache	Singh *et al.* 2011
Moraceae	*Ficus religiosa* L.	CHG 17	1582	**Peepal**	T	5	Bark	W	Bark used to treat skin	Joshi & Joshi 2000; Pradhan *et al.* 2020

									itching problems	
Moraceae	*Ficus semicordata* Buch-Ham.	CHG 14	1690	**Khanayo**	T	5	Leaf	W	Milky latex is used to treat kidney stone, given to animals after delivery for easy removal of placenta	Kunwar & Bussmann 2006
Myricaceae	*Myrica esculenta* Buch-Ham. ex D.Don	CHG 29	1960	**Hade kafal**	T	20	Bark and leaf	W	Used to stop bleeding in delivered women	Bhaila *et al.* 2022
Myrtaceae	*Psidium guajava* L.	CHG 65	1560	**Amba**	T	7.5	Leaf, fruits	C	Fresh leaves are chewed to control sugar level, indigestion	Ojha Khatri *et al.* 2021; Bhaila *et al.* 2022
Myrtaceae	*Syzygium cumini* (L.) Skeels	CHG 75	1595	**Jamun**	T	7.5	Fruit	C	Fruits taken in indigestion and constipation	Bhatt & Kunwar, 2020
Nephrolepidaceae	*Nephrolepis cordifolia* L.	CHG 31	1654	**Pani amala**	H	5	Rhizome	W	Appetizer, cooling tonic of the body	Tamang *et al.* 2017; Singh *et al.* 2018
Nyctaginaceae	*Mirabilis jalapa* L.	CHG 30	1521	**Lwang khursani**	H	5	Root	W	Root paste is used to control sugar	Not found
Oleaceae	*Jasminum mesnyi* Hance.	CHG 50	1538	**Jai phool**	S	5	Leaf	C	Tonsil, reduce pressure, leaf juice applied in khatira (red rashes on the body)	Not found
Oleaceae	*Nyctanthes arbor-tristis* L.	CHG28	1536	**Parijat**	T	50	Leaf, bark	C	Control sugar level, fever	Ojha Khatri *et al.* 2021

Phyllanthaceae	*Phyllanthus parvifolius* Buch-Ham. Ex D.Don	CHG 25	1546	**Khareti**	S	30	Root	W	Paste of roots with oil is applied on cuts and wounds	Shah & Lamichhane 2017
Phyllanthaceae	*Phyllanthus emblica* L.	CHG 33	1440	**Amala**	T	15	Fruit	C	Asthma, gastritis, throat pain	Singh *et al.* 2012; Gubhaju & Gaha 2019; Bhaila *et al.* 2022
Plantaginaceae	*Plantago major* L.	CHG 34	1665	**Thulo chiraite**	H	22.5	Root, leaf	W	Leaves used for fever; root used as anthelminthic in livestock	Tamang *et al.* 2017
Plumbaginaceae	*Plumbago zeylanica* L.	CHG 24	1590	**Chitu**	H	5	Root	W	Paste of root is taken as appetizer, abdominal disorder	Pradhan *et al.* 2020; Miya *et al.* 2021
Poaceae	*Imperata cylindrica* L.	CHG 84	1645	**Siru**	H	7.5	Root	W	Treat intestinal worm	Gubhaju & Gaha 2019; Budha-Magar *et al.* 2020; Bhaila *et al.* 2022
Poaceae	*Phalaris arundinacea* L.	CHG 22	1460	**Seto dubo**	H	45	Leaf	W	Leaf paste used to treat albinism (Dubi)	Not found
Poaceae	*Saccharum officinarum* L.	CHG 68	1765	**Ukhu**	S	5	Leaf	C	Taken by delivered women for easy fall of placenta, to cure jaundice	Adhikari *et al.*2019; Thapa 2020
Polygonaceae	*Polygonum* sp.	CHG 95	1398	**Pirre jhar**	H	5	Young shoot	W	Used to cure dysentery in livestock	Not found
Polygonaceae	*Rumex nepalensis* Spreng.	CHG 78	1545	**Halhale**	H	10	Rhizome	W	Paste of rhizome is applied to cure swelling	Singh *et al.*2012

Primulaceae	*Maesa chisia* Buch.-Ham. ex D.Don	CHG 94	1456	**Bilouni**	S	2.5	Root	W	Root bark used as insecticidal	Balami 2004; Mahato & Chaudhary 2005
Ranunculaceae	*Ranunculus sceleratus* L.	CHG 96	1625	**Thaple**	H	10	Root	W	Root juice act as appetizer	Not found
Rosaceae	*Rubus ellipticus* Sm.	CHG 66	1667	**Aaiselu**	S	37.5	Root	W	Root paste applied in cuts and wound, stomachache	Adhikari *et al.* 2019; Poudel *et al.* 2021; Bhaila *et al.* 2022
Rutaceae	*Aegle marmelos* L.	CHG 5	1694	**Belpatra**	T	15	Leaf, fruit	C	Used to treat fever, fruit decrease the sugar level, juice of fruit is used for constipation	Bhattarai 2017; Thapa 2020; Ojha Khatri *et al.* 2021
Rutaceae	*Citrus aurantifolia* (Christ.) Swingle	CHG 43	1789	**Kagati**	T	7.5	Fruit	C	Fruit juice applied in fracture part, decrease cholesterol	Ojha Khatri *et al.* 2021
Rutaceae	*Citrus medica* L.	CHG 45	1507	**Bimiro**	T	12.5	Fruit	C	Fruit is good for indigestion	Not found
Rutaceae	*Citrus reticulata* Blanco.	CHG 40	1547	**Suntala**	T	5	Fruit peel	C	Paste of cover applied as face mask to reduce pimples	Not found
Rutaceae	*Zanthoxylum armatum* DC.	CHG 39	1896	**Timur**	T	15	Seed	W	Seeds use for indigestion	Budha-Magar *et al.* 2020; Bhaila *et al.* 2022
Santalaceae	*Osyris wightiana* Wall.	CHG 26	1600	**Nundhiki**	S	62.5	Bark	W	Paste of bark is applied on fracture	Bhaila *et al.* 2022
Sapindaceae	*Sapindus mukorossi* Gaertn.	CHG 79	1861	**Reetha**	S	7.5	Fruit	C	Insecticidal, promotes hair growth	Pradhan *et al.* 2020

Saxifragaceae	*Astilbe rivularis* Buch.-ham. ex D. don.	CHG8	-	**Thulo okhati**	H	27.5	Root	W	Root paste given in pre and post pregnancy	Shrestha *et al.* 2016
Solanaceae	*Capsicum microcarpum* Cav.	CHG 91	1558	**Akabare khursani**	H	12.5	Fruit	C	Gastritis, indigestion	Pradhan *et al.* 2020; Bhaila *et al.* 2022
Solanaceae	*Datura metel* L.	CHG 86	1650	**Dhaturo**	H	5	Leaves	W	Used as appetizer and for cough	Tamang *et al.* 2017
Solanaceae	*Nicotiana tabacum* L.	CHG 36	1547	**Kancho pat**	S	2.5	Leaf	W	Leaf paste used in itching	Not found
Solanaceae	*Solanum lycopersicum* L.	CHG 77	1561	**Tamatar**	H	7.5	Fruit	C	Fruit juice applied on fire burnt area of the body	Not found
Solanaceae	*Solanum nigrum* L.	CHG 70	1562	**Kaligedi**	H	10	Fruit	W	Fever, gastric, cough	Ojha Khatri *et al.*2021
Solanaceae	*Solanum pseudocapsicum* L.	CHG 76	1405	**Khorsani phool**	H	5	Fruit	C	Piles	Not found
Solanaceae	*Solanum virginianum* L.	CHG 69	1545	**Kantakari**	H	30	Seed	W	Seed paste used for toothache	Bhaila *et al.*2022
Urticaceae	*Gonostegia hirta* Blume.	CHG 18	1526	**Maslari**	H	50	Root	W	Paste applied in fracture to reduce pain	Ojha Khatri *et al.* 2021
Verbenaceae	*Duranta erecta* L.	CHG 55	1589	**Nilkanda**	S	7.5	Whole plant	W	Used as anthelminthic, insect repellent	Srivastava & Shanker 2022
Zingiberaceae	*Amomum subulatum* Roxb.	CHG 4	1396	**Alainchi**	S	22.5	Fruit	C	Prevent sore throat	Paudyal *et al.* 2021
Zingiberaceae	*Curcuma caesia* Roxb.	CHG 41	1585	**Kalo haledo**	H	30	Rhizome	W	Used to treat gastritis, appetizer, blood purifier	Ojha Khatri *et al.* 2021; Poudel *et al.* 2021

Zingiberaceae	*Curcuma longa* L.	CHG 88	1545	**Beshar**	H	65	Rhizome	C	Decoction of rhizome used as antiseptic, boil in water and taken for cough, common cold, used as face cleanser and face mask	Bhattarai 2017; Adhikari *et al.* 2019; Gubhaju & Gaha 2019; Thapa 2020
Zingiberaceae	*Curcuma* sp.	CHG 56	1530	**Pahele**	H	45	Rhizome	W	Maintain appetite, used to treat body ache	Not found

H: herb, S: shrub, T: tree, Cl: climber; W : wild, C: cultivated.

For assessing homogeneity on the informants' knowledge, the factor of informants consensus (F_{IC}) for distinct disease categories was determined following Trotter and Logan (1986) and Heinrich *et al.* (2009).

$$F_{IC} = \frac{Nur - Nt}{Nur - 1}$$

Where N_{ur} is the number of use reports and N_t is the number of used plants for the treatment of different ailments.

Results and Discussion

Diversity of medicinal plants

A total of 96 plants belonging to 56 botanical families and 85 genera were documented from the study area (Table 1). Among total plant species, ninety-four species were used for humans and six species were used for livestock.

The families with the highest number of species were Solanaceae (7 species) followed by Asteraceae (6 species), Rutaceae (5 species), Lamiaceae (4 species), Zingiberaceae (4 species), Fabaceae (3 species), Poaceae (3 species) and Ericaceae (3 species) (Figure 3). Thirteen families represented 2 species each while the remaining 35 families constituted single species representation. The high number species under Solanaceae family may be due to the suited sub-tropical climatic condition to them. The widespread usage of Solanaceae has also been documented (Murad *et al.* 2013) and is typically attributed to their abundance of secondary metabolites including alkaloids and steroids (Ullah *et al.* 2014). The dominancy of Asteraceae might be due to the reason that it is the largest family of flowering plants, and their members are found in every region of the globe except Antarctica (Ansari *et al.* 2017). Moreover, the presence of high number of species under Asteraceae family may be due to their bioactive compounds (Thomas *et al.* 2009).

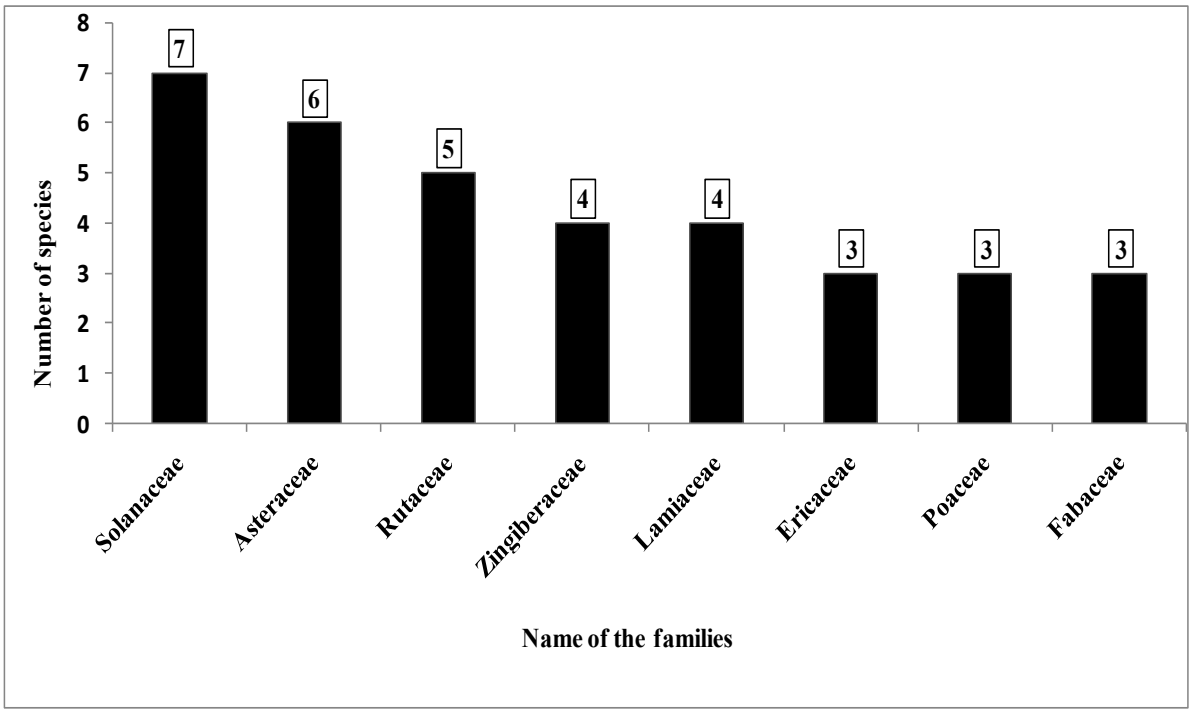

Figure 3. Most dominant families in the study area with their respective number of species

Knowledge distribution among genders and age groups

Young teenagers below the age of 20 were not interested in the present investigation due to the lack of knowledge regarding medicinal plants. Moreover, no respondents below 20 years of age were involved in the study of Bhaila *et al.* (2022). According to the Pearson correlation (r = 0.708) and a linear regression (R^2 = 0.502) (Figure 4), old - aged people were found to have a sound knowledge of medicinal plants in comparison to young people (Figure 4). The result was also supported by Mussarat *et al.* (2014), Ojha Khatri *et al.* (2021), Bhaila *et al.* (2022), and Magar *et al.* (2022) where old-aged people had more knowledge compared to young people regarding medicinal plants. Moreover, we observed a significant difference (p-value < 0.001) between the men and women regarding the number of medicinal plants described by them (Table 2). Women vast knowledge of medicinal plants may be due

to the fact that most women in rural communities are active in household activities and spend more time at home collecting wood, timber, local vegetables, and herbs from their surroundings (Figueiredo *et al.* 1997, Voeks & Leony 2004, Quinlan and Quinlan 2007, Mussarat *et al.* 2014).

Table 2. Chi-square test between the genders and number of plants described by them.

	Men	Women	
Number of total plants described	68	87	X^2 =10.84
Number of undescribed plants	28	9	p-value < 0.001
Total number of plants	**96**	**96**	

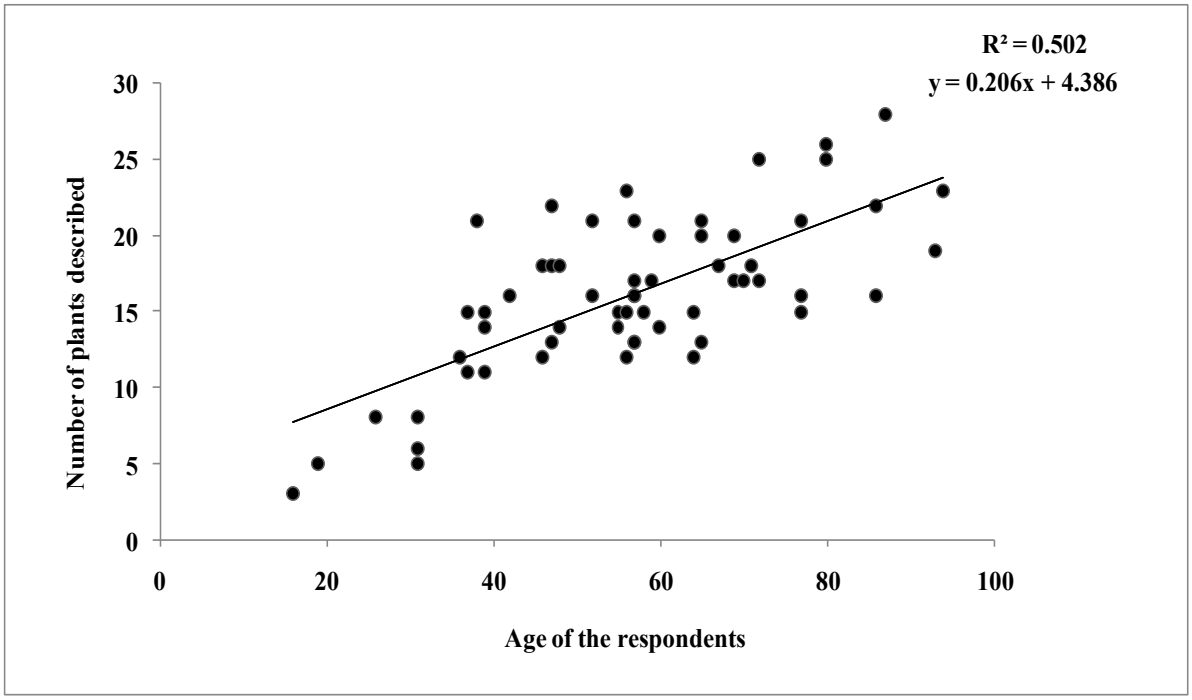

Figure 4. A simple linear regression between the age of respondents and the number of plants described by them

Habit, habitat and plant parts used

The majority of the species were herbs (47 species), followed by trees (23 species), shrubs (21 species) and climbers (5 species) (Figure 5). Similar findings were reported by Uprety *et al.* (2010), Ojha Khatri *et al.* (2021), Bhaila *et al.* (2022) and Magar *et al.* (2022) in which herbs were the primary sources of medicinal plants. It might be due to the easy collection, storage, transportation, and extraction of active components from herbs than other forms (Shrestha & Dhillion 2003). Moreover, herbs contain important secondary metabolites in higher amount for their life strategies (Stepp & Moerman 2001). Among the documented plant species, 56 species (58%) were collected in the wild and 40 species (42%) were cultivated (Table 1).

The most frequently used part was leaves (n = 30), followed by roots (n = 17), fruits (n = 15), barks (n = 11), rhizomes (n = 8), shoots/aerial part (n = 9), seeds (n = 6), flowers (n = 3), whole plant (n = 3), stems (n = 2), tuber (n = 1) and latex (n = 1) (Figure 6). The local people of Changunarayan had used leaves vigorously for medicinal purposes. Leaves are an important part of nutrient synthesis; they have a higher biochemical activity, which could be a reason for their frequent use as medicine (Poudyal *et al.* 2012). Similar results were also reported by Acharya and Acharya (2009), Singh (2017), and Chaudhary *et al.* (2020) from other parts of the country where leaves were used mostly among the plant parts.

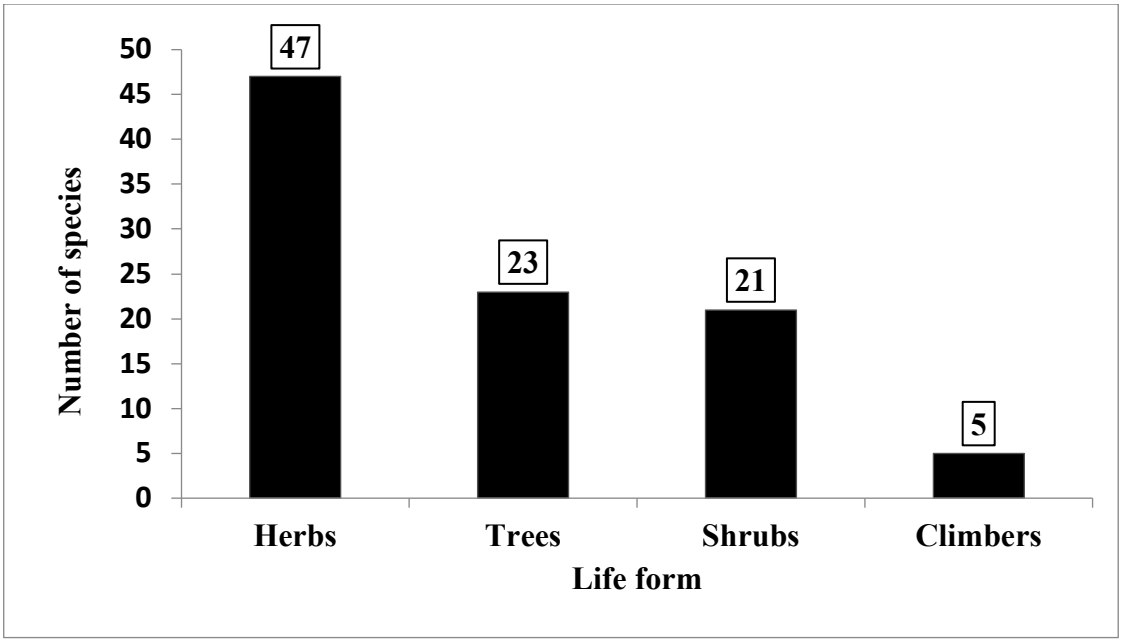

Figure 5. Life form of the plant species

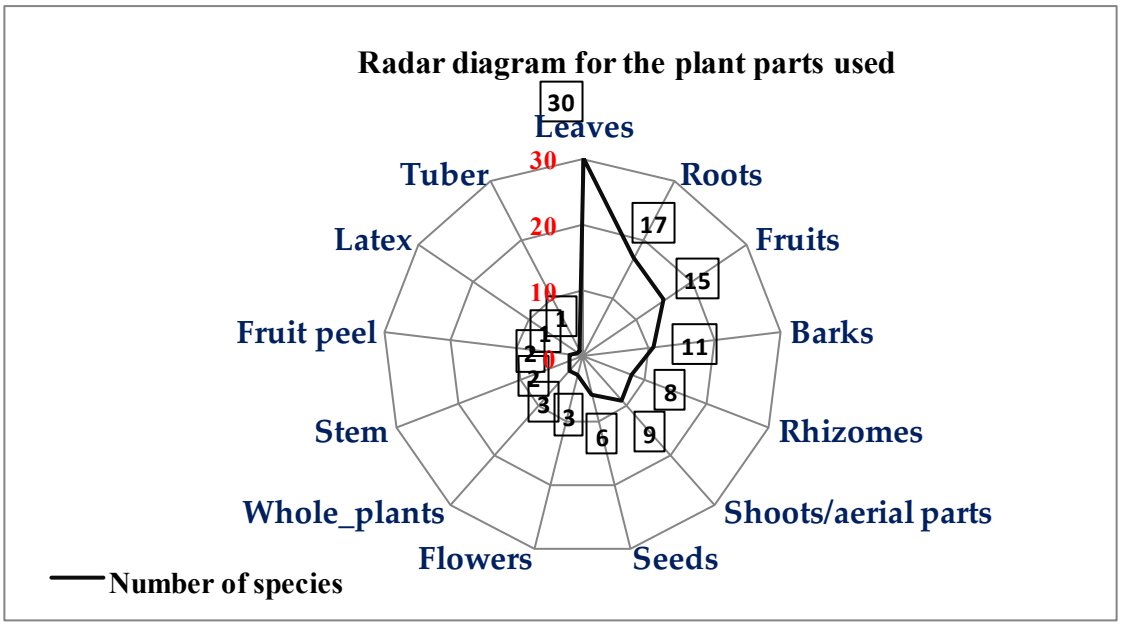

Figure 6. Different parts of the plant used for medicinal purpose

Frequency index and Informants consensus factor

Altogether 40 different ailments were recorded, which were treated by using different plant species. Fever, cough, cold, stomachache, throat pain, indigestion, skin problems, constipation, fracture, dysentery, and diarrhea were the most commonly treated ailments. The ailments treated by many plants in the present study agreed with the previous studies (cited in Table 1). This makes clear that the use of medicinal plants by the local people of Changunarayan was reliable. However, medicinal use of twenty-one plants was not found in the searched ethnomedicinal literatures of Nepal, which may be the new use to ethnomedicinal practices in Nepal.

The frequency index showed that *Ocimum tenuiflorum* and *Curcuma longa* were the most used plant species, having a frequency index of 65% (Figure 7) while *Lobelia pyramidalis, Maesa chisia, Nicotiana tabacum,* and *Semecarpus anacardium* were the least utilized, with a frequency index of 2.5% (Table 1). The aerial parts of *Ocimum tenuiflorum* contain different medicinal compounds like phenolics, flavonoids, essential oil, steroids, and fatty acid derivatives (Singh & Chaudhuri 2018) and the plant is used against fever and cough. According to religious belief

of Hindus in Nepal, the next reason behind the high frequency index of *Ocimum tenuiflorum* (**Tulsi**) may be because Hindu Nepalese worship **Tulsi** as their religious plant, which is seen almost in every person's house. In addition to this, the leaves of **Tulsi** contain euginal, urosolic acid, eugenol, carvacrol and limatrol (Pattanayak *et al.* 2010). Among the available chemicals, eugenol is highly responsible for therapeutic potentials (Pattanayak *et al.* 2010). *Azadirachta indica* and *Centella asiatica* were moderately known plant species. *Azadirachta indica* were used to maintain sugar and pressure level in the body while *Centella asiatica* is used as urine purifier and memory booster. Phytochemicals such as saponins, reducing sugars, tannins, glycosides, alkaloids and flavonoids were found in the leave extracts of *Azadirachta indica*, which are often used supplements to treat a range of health problems and skin irritations (Dash *et al.* 2017). *Centella asiatica* was also moderately known plants according to the frequency index calculated by Rajbanshi and Thapa (2019).

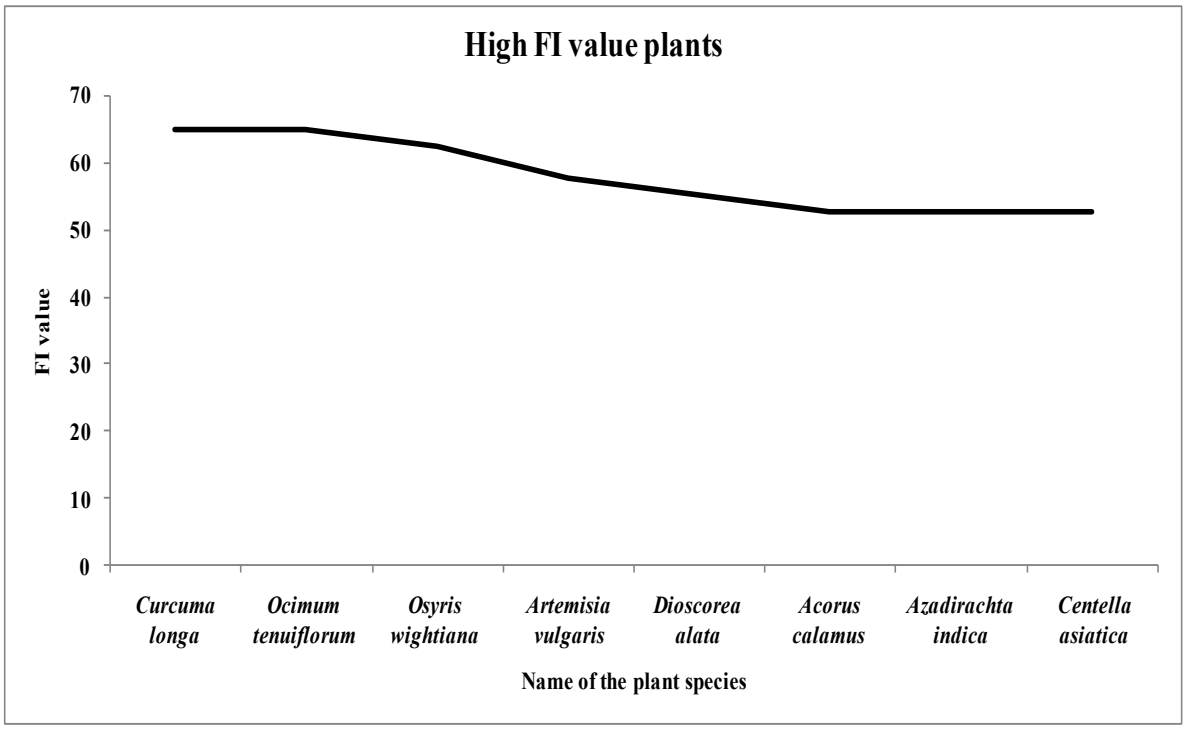

Figure 7. Top eight plant species with highest FI values

Consensus analysis in ethnobotanical research gives a measure of dependability for every given claim that provides credible evidence, and their product runs from 0 to 1 (Singh *et al.* 2012). For the purpose of investigating the factor of informant consensus, reported forty distinct diseases were divided into 11 categories based on Singh *et al.* (2012) (Table 3). In our study, the FIC value varied from 0.40 to 0.90. Fever had the highest FIC value (0.90), followed by miscellaneous (0.86), dermatological condition (0.85), gastro-intestinal disorder (0.81), oral and dental disorder (0.80) (Table 4). However, the average F_{IC} value was recorded to be 0.74 and least agreement of respondents was on cardio-vascular disorder (0.40). A high F_{IC} value implies that informants agree on taxon selection, whereas a low number indicates disagreement (Raghupathy *et al.* 2008). Many researchers (Singh *et al.* 2012, Shrestha *et al.* 2014, Malla *et al.* 2015, Shrestha *et al.* 2016, Poudel *et al.* 2021) from Nepal have used this method to check the agreement of respondents in particular medicinal plants, for treating any ailments. All those previous studies revealed that the use of medicinal plants for the treatment of various human illnesses is still in practice across different ethnic groups. The present study also supports the use of medicinal plants by the local people of the study area and their agreements on use of taxa. Although different ethnic groups were present in our study, a high F_{IC} value in our study might be due to the presence of all the plants in the same community and same geographical region. Fever had a highest F_{IC} value, which has been given higher priority in the present study. This might be due to the fact that fever is the most prevalent and often occurring main health issue in humans, and the local people of Changunarayan have been creating their own treatment methods by examining the medicinal potential of various plant species. A particular plant species was used for one or more than one ailment category in the study. In the present study, the species were found to be used for one, two, three or five ailments categories. *Artemesia vulgaris* was used to treat fever, dermatological disorders, gastro-intestinal disorders, cardio-vascular disorders and miscellaneous ailments.

Cannabis sativa, and *Polygonum* sp. were used to treat dysentery in livestock while *Cissampelos arenicola* and *Ficus semicordata* were used to stop bleeding in livestock and for easy removal of placenta after delivery respectively (Table 1). However, *Cyperus rotundus* and *Plantago major* were used as anthelmintic in livestock. The use of *Cannabis sativa* against dysentery in cattle, pigs, goats and sheep was also reported which showed agreement to our study (Gakuubi & Wanzala 2012). The number of plants in our study used to treat livestock was very less in number which showed the less utilization of plants in material medica of livestock.

Table 3. List of eleven different ailment categories in the study

Ailment categories	Different ailments included under particular category
Respiratory disorder	Pneumonia, cough, cold, asthma
Skeleto- muscular pain	Swelling, fracture, body pain
Dermatological disorder	Cuts, burns and wounds, skin problems, antiseptic, albinism, hair growth
Mental aliments	Memory booster
Gastro-intestinal disorder	Constipation, Diarrhea, Dysentery, Piles, Appetizer, Anthelminthic
Ureo-genital disorders	Urine purifier, Stone problem, Menstruation, Fertility
Oral and dental disorders	Tooth problems
Ear, Nose, Eye, Throat problems	Sinusitis, Ear problems, Eye problems, Throat problems, Neck problems, Heck stuck
Fever	Fever
Cardio- vascular disorder	Blood pressure, Blood purifier
Miscellaneous	Diabetes, Cholesterol, Lactation, Delivery, Jaundice

Table 4. List of medicinal plants used for the treatment of different ailments and respective F_{IC} value for every ailment category.

Ailment categories	Medicinal plants used for ailments	Number of Plants used (N_t)	Number of use reports (N_{ur})	F_{IC} value
Fever	*Nyctanthes arbor-tristis, Achyranthes aspera, Aegle marmelos, Azadirachta indica,* ***Artemisia vulgaris, Justicia adhatoda, Cirsium wallichi, Mentha arvensis,*** *Ocimum tenuiflorum, Solanum nigrum*	10	92	0.90
Respiratory disorder	*Acorus calamus,* ***Cinnamomum tamala,*** *Curcuma domestica,* ***Mentha piperita,*** *Ocimum tenuiflorum,* ***Ammomum subulatum, Phyllanthus emblica, Dioscorea alata, Tagetes erecta, Vitex negundo***	10	43	0.78
Skeleto- muscular pain	*Citrus aurantifolia,* ***Osyris wightiana, Gonostegia hirta, Asparagus racemosus, Bauhinia variegate***	5	18	0.76
Dermatological disorder	***Ageratina adenophora,*** *Aloe vera, Curcuma* sp., ***Euphorbia royleana, Macrotyloma uniflorum, Rubus ellipticus, Artemisia vulgaris, Solanum lycopersicum, Citrus sinensis, Dolichos lablab, Ficus religiosa, Colocasia esculenta, Rumex nepalensis, Gaultheria fragrantissima, Sapindus mukorosi, Phalaris arundinacea***	16	101	0.85
Mental aliments	***Centella asiatica,*** *Asparagus racemosus*	2	4	0.66
Gastro-intestinal disorder	***Allium sativum, Bauhinia variegata, Capsicum microcarpum, Coriandrum***	31	162	0.81

	sativum, *Curcuma* sp., *Curcuma caesia,* ***Dioscorea deltoidea***, ***Drymaria cordata, Zanthoxylum armatum***, ***Citrus medica***, ***Solanum pseudocapsicum***, ***Cannabis sativa, Cynoglossum zeylanicum***, ***Oroxylum indicum, Polygonum* sp**, ***Artemisia vulgaris***, ***Duranta repens, Juglans regia***, ***Melia azedarach***, ***Semecarpus anacardium, Imperata cylindrica, Cyperus rotundus***, ***Datura metel, Plumbago zeylanica, Rannunculus sceleratus, Nephrolepis cordifolia***, *Aegle marmelos*, ***Allium sativum***, *Aloe vera*, ***Syzygium jambos, Cuscuta reflexa, Saccharum officinarum*			
Ureno-genital disorders	*Aloe vera, Asparagus racemosus,* ***Cissampelos pariera***, *Achyranthes aspera,* ***Myrica esculenta***, ***Astible rivularis***, ***Lobelia pyramidalis, Centella asiatica***, ***Terminalia chebula, Hibiscus rosa sinensis***, ***Cucumis sativus, Ficus semicordata, Macrotyloma uniflorum***	13	34	0.63
Oral and dental disorders	*Juglans regia, Solanum xanthocarpum*	2	6	0.80
Ear, Nose, Eye, Throat problems	*Acorus calamus,* ***Jasminum mesyni***, ***Rhododendron arboreum, Berberis aristata, Berberis napaulensis, Bryophyllum* sp.**, ***Sonchus oleraceus***	7	29	0.78
Cardio- vascular disorder	***Artemesia vulgaris***, *Azadirachta indica,* ***Momordica charantia***, *Curcuma caesia*	4	6	0.40
Miscellaneous (Diabetes, Cholesterol,)	*Aegle marmelos,* ***Artemesia vulgaris***, ***Mirabilis jalapa***, ***Nasturtium officinale***, *Nyctanthes arbor-tristis,* ***Psidium guajava***, ***Smallanthus sonchifolius***, *Azadirachta indica, Citrus aurantifolia,* ***Persea Americana***	10	69	0.86

Names of species in bold and italic represent a plant used for one ailment category; only italic represents two ailment categories; italic and underlined represents three ailment categories; bold, italic and underlined represents five ailment categories.

Threats and cultivation

Most of the medicinal plants were collected from the wild for the treatment of various ailments prevalent in the study area. However, this study revealed that the practice of cultivating (including in pots, gardens and fields) useful medicinal and ornamental plants in the study area was quite good. Most of the households have been practicing cultivating many medicinal herbs in their pots and gardens. However, three households have been cultivating *Asparagus racemosus, Tagetes erecta, Citrus limon* and *Astilbe rivularis* in their cultivating fields. This study recommends the cultivation of medicinal plants in their fields rather than in pots and gardens for economic demands. This will help decrease the harvesting pressure of those plants in the wild. Harvesting of medicinal plants is found to be commonly practiced worldwide (Kadir *et al.* 2012, Timalsina & Singh 2014). According to the information provided by the respondents, the number of medicinal plants in the study area was decreasing day by day. Most of the respondents (40%) reported that habitat degradation was a major threat to medicinal plants. After habitat degradation, 30% of respondents pointed out improper harvesting as a crucial threat, followed by overexploitation (19%), illegal trade (7.5%) and grazing (5%) (Figure 8).

These plants provide a significant contribution to the treatment of human and cattle illnesses. Improper harvesting, illicit trading, habitat destruction, grazing, and overexploitation were discovered to be the fundamental reasons of their decline. Resources are being exploited and environments are being destroyed as a result of expanding urbanization and industrialization, as well as unabated population increase and human interventions. Medicinal plants from different parts of Nepal have been discovered to be threatened in the same way (Bhattarai *et al.* 2010, Hasan *et al.* 2013, Kumari *et al.* 2012, Malla *et al.* 2015). As a result, developing proper conservation methods for quickly growing medicinal plants is critical in order to avoid natural resource depletion (Singh 2013).

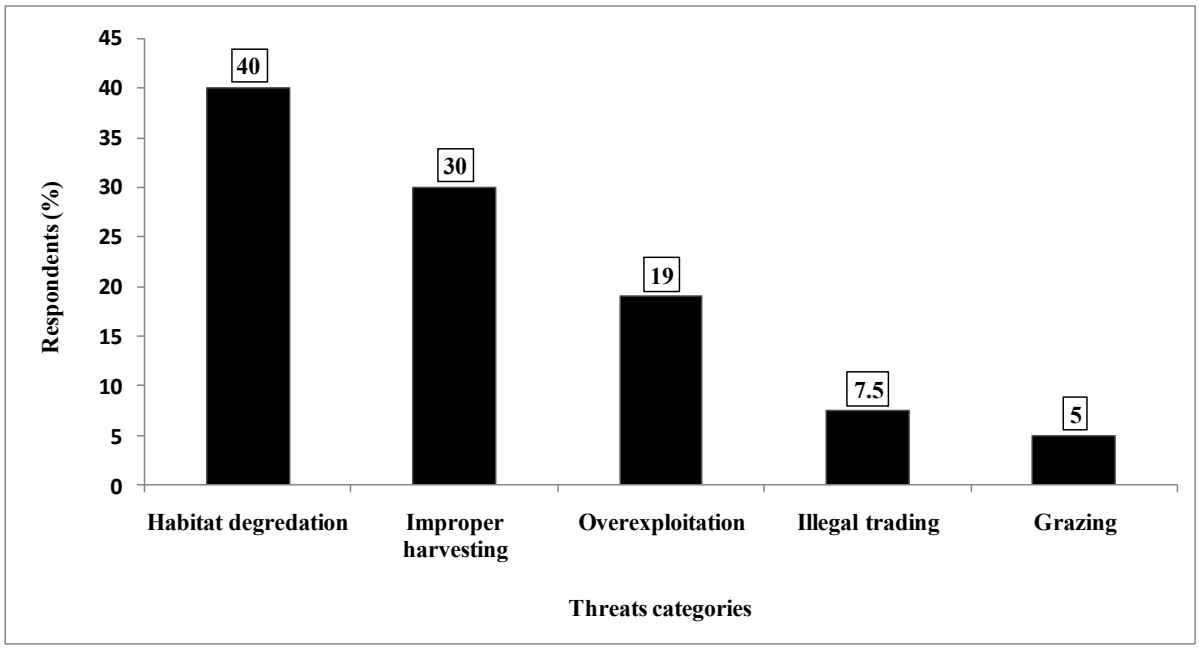

Figure 8. Major threats to the medicinal plants of the study area.

Conclusions

Though the study area was very near to the capital city, local people are still using medicinal plants for their primary health care.. A large number of species were used to treat fever and gastrointestinal disorders, which indicates their higher prevalence in the area. Moreover, the plants in the study area must be rigorously tested for possible bioactive components that can aid in the development of innovative medications using phytochemical and pharmacological methods. The majority of the medicinal plants documented in the present study chiefly belong to the Solanaceae, Asteraceae, Rutaceae, Lamiaceae, and Zingiberaceae. Herbs made up the highest proportion of medicinal plants, and leaves were the most frequently used plant part. The species used for medicinal purposes are collected mostly from the wild, and only a few of them are cultivated. Population of many medicinal plant species are found to be under threat due to grazing, over exploitation, habitat degradation, illegal trade, and improper harvesting. To conserve the medicinal plant variety in the study area, a proper conservation planning is required. It can be accomplished by enlisting the help of the local community to build a medicinal plant garden. The study also showed that traditional knowledge was more confined to elderly people, which indicates the chances of extinction of such knowledge. Thus, it is necessary to acquire and preserve the traditional system of medicine through proper documentation and identification of plant species.

Declarations

List of abbreviations: H: herb, S: shrub, T: tree, Cl: climber, W: wild, C: cultivated

Ethics approval and consent to participate: All the participants provided prior informed consent before the interviews.

Consent for publication: No personal data are published

Availability of data and materials: All data collected in the study has been presented and visualized in the manuscript.

Conflicts of interest: The authors declare to have no conflict of interest.

Funding: Not applicable

Authors' contributions: KD, NNM, and SS designed the study. KD, NNM, NS and SS collected the data. NNM and SC performed the data analysis. KD, NNM, SC and YU drafted and finalized the manuscript.

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