



Ecological and ethnobotanical values of weeds found in the spring rice fields in Chitwan, Nepal

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Abstract

Background: The reliance of human beings on plants for different purposes such as medicine, fodder, fuel, and shelter is fading away, primarily, due to increasing dominance of market economy globally in the recent decades. Ethnobotanical study, especially that of weeds, is playing a crucial role in establishing the relationship between weeds and people, thereby documenting important uses of such weeds. Chitwan, located in the central part of Terai, is considered the grain basket of Nepal. The district is relatively advanced in agriculture, with higher agricultural productivity than that in most of the country. Spring rice cultivation is prevalent in the area. Weed infestation is one of the severe problems adversely affecting rice cultivation. These weeds have different ethnobotanical values for indigenous ethnic groups as well as residents.

Methods: Ecological survey was carried out in four distinct sites: the rice fields of the Institute of Agriculture and Animal Science, Gitanagar, Champanagar, and Ujjalnagar of Chitwan, Nepal. Weeds were collected from three randomly placed one-square-meter quadrats in each rice field. The ethnobotanical uses of the weeds were explored via key informant surveys with traditional healers from Tharu and Darai ethnic groups and the Brahmin caste in Mangalpur, Gitanagar, Champanagar, and Ujjalnagar.

Results: Weed flora of 53 species belonging to 43 genera and 22 families were reported in the spring rice fields. Cyperaceae (twelve species), Compositae (five species), Fabaceae (four species), Linderniaceae (four species), Plantaginaceae (four species), Poaceae (four species), and Amaranthaceae (three species) were the families with the largest representation, accounting for approximately 68% of all weeds. The most common weeds were *Spirodela polyrrhiza* (L.) Schleid., *Cyperus difformis* L., *Azolla* Lam., *Lindernia procumbens* (Krock.) Philcox, *Mecardonia procumbens* (Mill.) Small, and *Fimbristylis quinquangularis* (Vahl) Kunth. These weeds also possess different ethnobotanical values, the most common being medicinal and fodder values.

Conclusions: This study reveals the significance of weeds as medicine along with their medicinal values. People still rely on such plants as a primary healing resource. In addition, weeds can be used as fodder for livestock and have other important uses in local daily life. Hence, there is a dire need to spread awareness regarding ethnobotanical uses of weeds found in spring rice fields in Chitwan. This can possibly contribute to the sustainable uses of weeds, rather than grossly eliminating them from the field, which poses a threat to their extinction.

Keywords: Fodder, Important Value Index, Medicine, Summed Dominance Ratio, Tharu

Background

It is well known that a crop grown alone cannot exist; some unwanted plant species also exist in the field that we call “weeds.” These weeds compete with crops for light, space, water, and mineral nutrients resulting in low-quantity as well as low-quality grain production, thus adversely affecting human welfare (Dangol *et al.* 1988; Shrestha *et al.* 2018; Jaisi *et al.* 2020). Weeds and weed management is perceived as one of the severe problems in spring rice production in Chitwan (Jaisi *et al.* 2020). Losses in rice production alone range from 5% to 100% depending on the type of weeds, its intensity, and soil fertility (Dangol *et al.* 1988). Thus, there is a need of weed survey studies for their proper management to reduce losses caused by them. Such survey in Nepal can be traced back to 1965 when it was first conducted by M Numata in Eastern Nepal and followed by RL Chaudhary (1968 and 1971) in the southern part (Bhatt *et al.* 2021). Since then, several types of research have been conducted involving various crop fields across Nepal (Bhatt *et al.* 2021). Surveys of weeds in rice fields can also be found (Dangol *et al.* 1986; Dangol *et al.* 1988; Dangol & Bhattarai 1993), but those for spring rice are largely missing.

Each plant, including weeds, has certain benefits. Different ethnic groups or societies use plants for different purposes. Beneficial uses significantly contribute to rural society (Manandhar 1997). In addition, the importance of ethnobotany to identify plant species for conservation and sustainable community development has been acknowledged in the literature (Rijal 1997; Shengji 1997; Shrestha 1997; Bhat 2019). Ethnomedicine based on traditional knowledge is a good example, contributing to poor communities’ handling of different health issues (Singh *et al.* 2014; Amjad *et al.* 2015; Arunesh *et al.* 2018; Bhatt & Kunwar 2020; Budha-Magar *et al.* 2020; Pangani *et al.* 2020; Pradhan *et al.* 2020; Bhatt *et al.* 2021). Such uses are important, especially in rural areas where modern health care facilities are either unavailable or out of reach to the poor. Hence, such traditional knowledge (ethnomedicine), which can also be regarded as Ayurveda, herbal medicine, and traditional and complementary medicine, can significantly contribute to Sustainable Development Goal 3 (WHO, 2019). This justifies researching the ethnobotanical uses of weeds, which are otherwise discarded. Hence, this study records the weeds found in the spring rice fields and their ethnobotanical value for Chitwan’s Tharu, Darai, and Brahmin ethnic/caste groups. Chitwan is among the few districts where rice, including spring rice, is intensively grown (MoALD 2020). The district is also a home for diverse caste and ethnic groups immigrated from all around the country including its own indigenous ethnic groups like Tharu and Darai. It is hypothesized that the weeds in spring rice fields and plants around the spring rice fields have ethnobotanical value for indigenous ethnic groups like Tharu and Darai as well as the Brahmins, an immigrant caste group, in the study area. The anecdotal evidence suggests that indigenous ethnic groups like Tharu and Darai possess rich traditional knowledge on plant uses. Similarly, Brahmins also use plants for different daily purposes. Since ethnobotanical studies of weeds in spring rice are largely missing, and ethnobotanical studies focus primarily on indigenous ethnic group, this study contributes to filling such research gap by studying the ethnobotanical uses of weeds reported in spring rice by Brahmins, besides two ethnic groups in Chitwan.

Materials and Methods

Study area

Chitwan is a centrally located developed district of Nepal in terms of infrastructure, transport, communication, and other facilities, alongside the implementation of improved agricultural technologies and practices. Most farmers are now engaged in agriculture year-round. They do not pursue rice cultivation only during the normal season (i.e., Aashad), but also during spring, which is known as “spring rice” (FAO 2002). Hence, rice is intensively grown in Chitwan during both seasons; monsoon (June–November) and spring (February–July), contributing to around 68% of the district’s cultivable area under cereal production (MoALD 2020). Chitwan is among the districts with the highest land area under spring rice cultivation.

After considering the prevalence of spring rice production, four locations in Chitwan district were selected for this study. Three settlements, namely, Gitanagar, Champanagar, and Ujjalnagar, in the then Gitanagar Village Development Committee (VDC) (approximately 27°36′N 84°23′E with an elevation of 192 meters above mean sea level-masl), as well as farmland of the Institute of Agriculture and Animal Science (IAAS), located in the then Sharadanagar VDC (approximately 27°38′N 84°21′E with the elevation of 185 masl), were the four locations (Figure 1). After the restructuring of local governance in Nepal (2017), Gitanagar VDC and Sharadanagar VDC were merged with the then Bharatpur sub-metropolitan city to form the present Bharatpur Metropolitan City. These study settlements are now designated as Ward No. 6 (in the case of Gitanagar) and No. 13 (in the case of Champanagar and Ujjalnagar) of Bharatpur Metropolitan City. The farmland of IAAS is now located in Ward No. 19 of Bharatpur Metropolitan City. The IAAS farmland is low land with poor drainage or a swampy land. Waterlogging in the fields

promotes weeds in the spring rice fields of IAAS farmland. In contrast, in the other three locations, water is properly managed in the spring rice fields. The main motive behind selecting the IAAS farmland as one of the four study locations is to represent the special case of spring rice field in swampy land as well in this study.

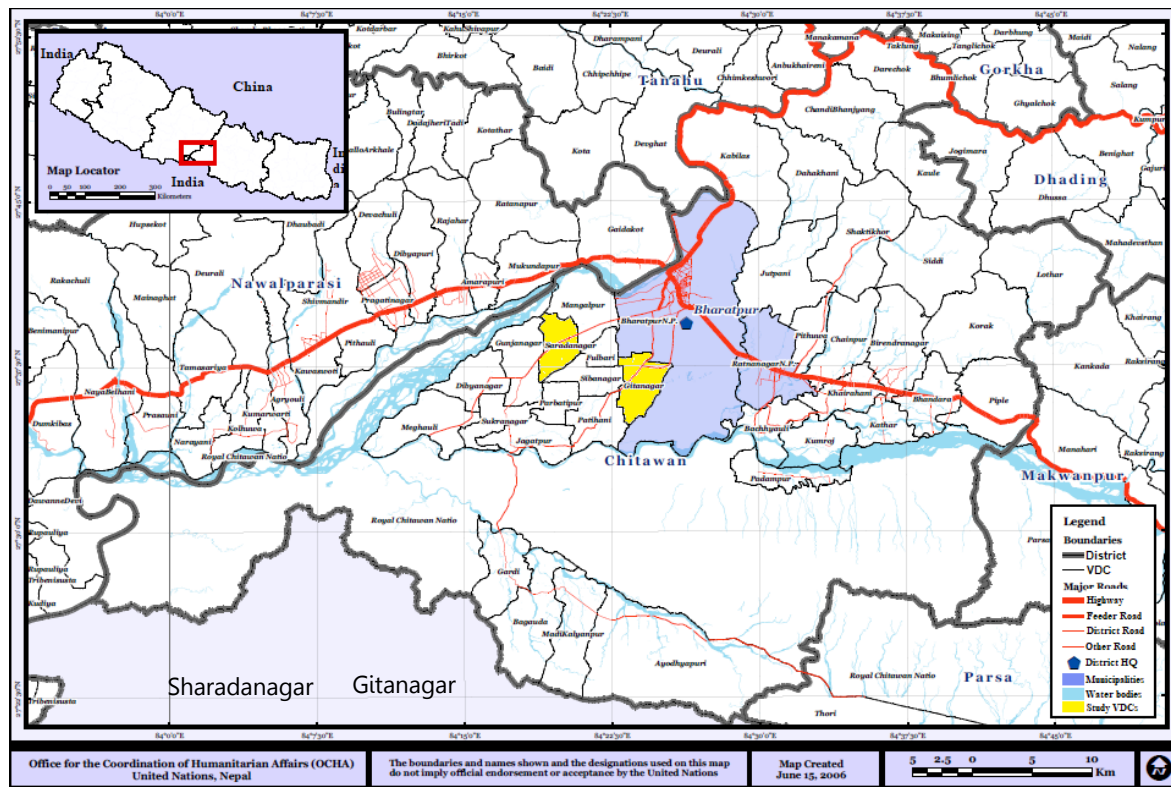


Figure 1. Map of Chitwan showing the study's Village Development Committees (UN 2006)

Ecological study

Spring rice growing season in Nepal is February/March to June/July, which in case of Terai and inner Terai is delayed by 2–4 weeks (MoAD, 2015). Hence, the ecological survey was carried out in four spring rice fields, one each at the IAAS farmland, Gitanagar, Champanagar, and Ujjalnagar, located in Chitwan, Nepal, in early July 2002, while the spring rice was still standing in the field.

Weeds were uprooted from an area within one-meter square quadrats randomly selected in three locations in each spring rice field. Herbarium sheets were prepared for each reported weed species by pressing each of them under a separate newspaper sheet in the field. Each of the herbaria was tagged for identification together with some of the characteristic features of those weeds such as habit, habitat, and flower color on the same page. All remaining weeds, uprooted from the quadrats, were collected in separate polythene bags. The species collected in polythene bags, representing different quadrats, were counted in an ecological analysis, more specifically, density, abundance, frequency, relative density, relative abundance, relative frequency, and importance value index (IVI) (Pancho & Kim 1985; Zobel *et al.* 1987).

An expert in the Department of Agricultural Botany, IAAS, Chitwan, was consulted for the identification of weed species reported in the paddy rice fields using the herbariums and the noted characteristic features. A book titled *Annotated checklist of the flowering plants of Nepal* by Press *et al.* (2000) was used for cross-validation. The scientific name of the identified plant species and their families were updated referring to World Flora Online <http://www.worldfloraonline.org/> (August 6, 2021) (WFO, 2021).

Ethnobotanical survey and data analyses

For the ethnobotanical survey, additional weeds/plants found up to around 3 m from the spring rice fields, which was set arbitrarily, were also collected. Herbarium of the collected weeds were prepared and identified along with the weeds reported in the spring rice field for the ecological survey. Ethnobotanical surveys of the weeds reported in and around the spring rice fields were conducted through key informant surveys. Eminent practitioners/healers

in the vicinity of the spring rice fields were identified and considered for key informant interviews (ethnobotanical surveys). The key informants interviewed in August and early September 2002 included one from Tharu ethnic group (identified as NRM), in Bangain settlement, in Sharadanagar VDC; one from Darai ethnic group (identified as RBD), in Mangalpur settlement, close to IAAS farm; and two from Brahmin caste (identified as F.Ac. and M.Ad.), in Ujjalnagar settlement and Champanagar settlement, respectively. The key informants were fully informed regarding the research, and verbal consent was obtained to participate in the interview and publish the information provided, whenever applicable. Confidentiality was also maintained as per the ISE Code of Ethics (ISE 2006). All the key informants are well known in their localities as Vaidyas, traditional healers using plants. Thus, they knew the ethnobotanical uses of different plant species existing in their surroundings. The interview involved the use of a checklist that included the local name of the weeds collected from the quadrat surveys as well as plants/weeds collected from around the spring rice fields, and their ethnobotanical uses. For the plants having medicinal value, the checklist alone included methods of use and medicinal value. The collected information was qualitatively analyzed.

Results and Discussion

Ecological analysis

Fifty-three identified and one unidentified species belonging to 43 genera and 22 families were found in the surveyed spring rice fields (Figure 2). The reported number was close to that delineated by Manandhar *et al.* (2007) in the paddy field at Kirtipur, that is, 52 weed species. Among the 22 families, 15 come from Dicotyledonae, six from Monocotyledonae, and one from Pteridophyta (*Azolla* Lam). The families that contributed more species were Cyperaceae (twelve species), Compositae (five species), Fabaceae (four species), Linderniaceae (four species), Plantaginaceae (four species), Poaceae (four species), Amaranthaceae (three species), Lythraceae (two species), Polygonaceae (two species), and the rest of the families had one species each (Figure 2).

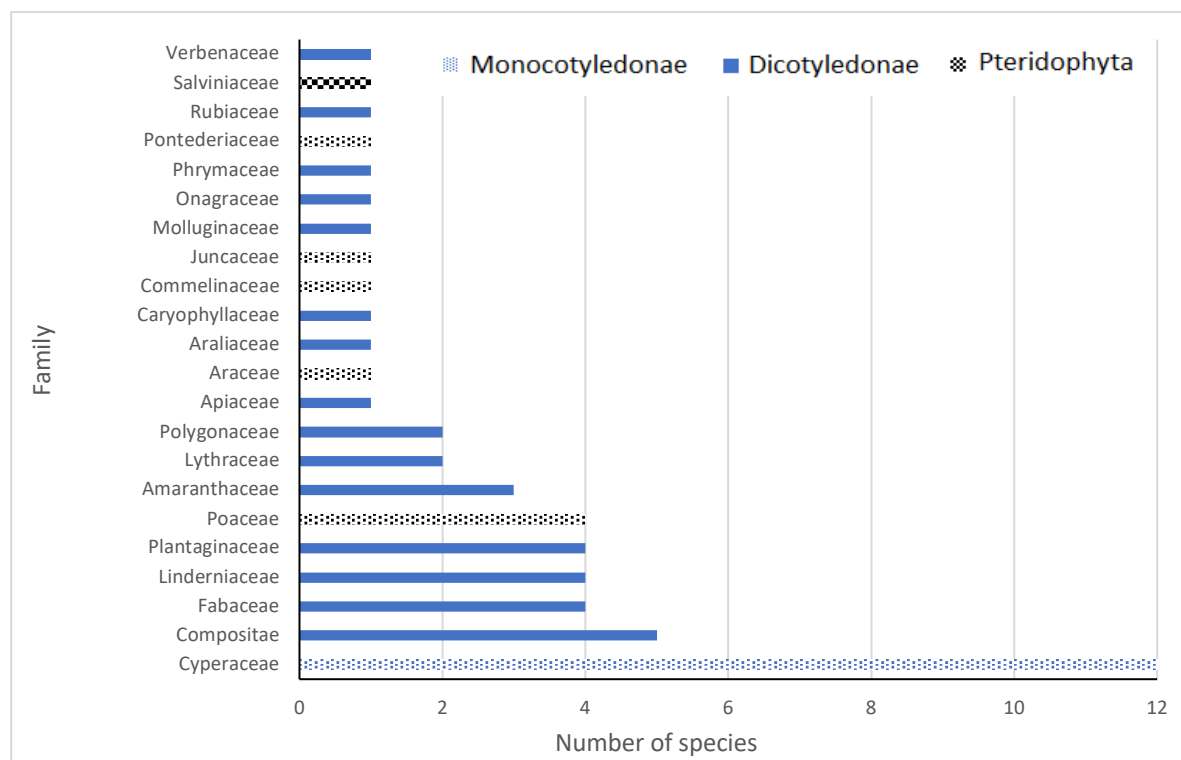


Figure 2. Number of species per family in the study sites

Among all these 53 species, *Spirodela polyrrhiza* (L.) Schleid., a monocot species belonging to the Araceae family, had higher density, abundance, relative density, and relative abundance, but the frequency and relative frequency were low, which indicates that these weeds were mostly found in Champanagar, Ujjalnagar, and Gitanagar; they were not found in the lowlands at the IAAS farm, which was marshy land. *Azolla* Lam. had a relatively higher abundance. Its occurrence was confined to the marshy land rice field of IAAS. *Alternanthera sessilis* (L.) R.Br. ex DC., *Fimbristylis quinquangularis* (Vahl) Kunth, *Cyperus difformis* L. and *Lindernia procumbens* (Krock.) Philcox were found throughout the study area.

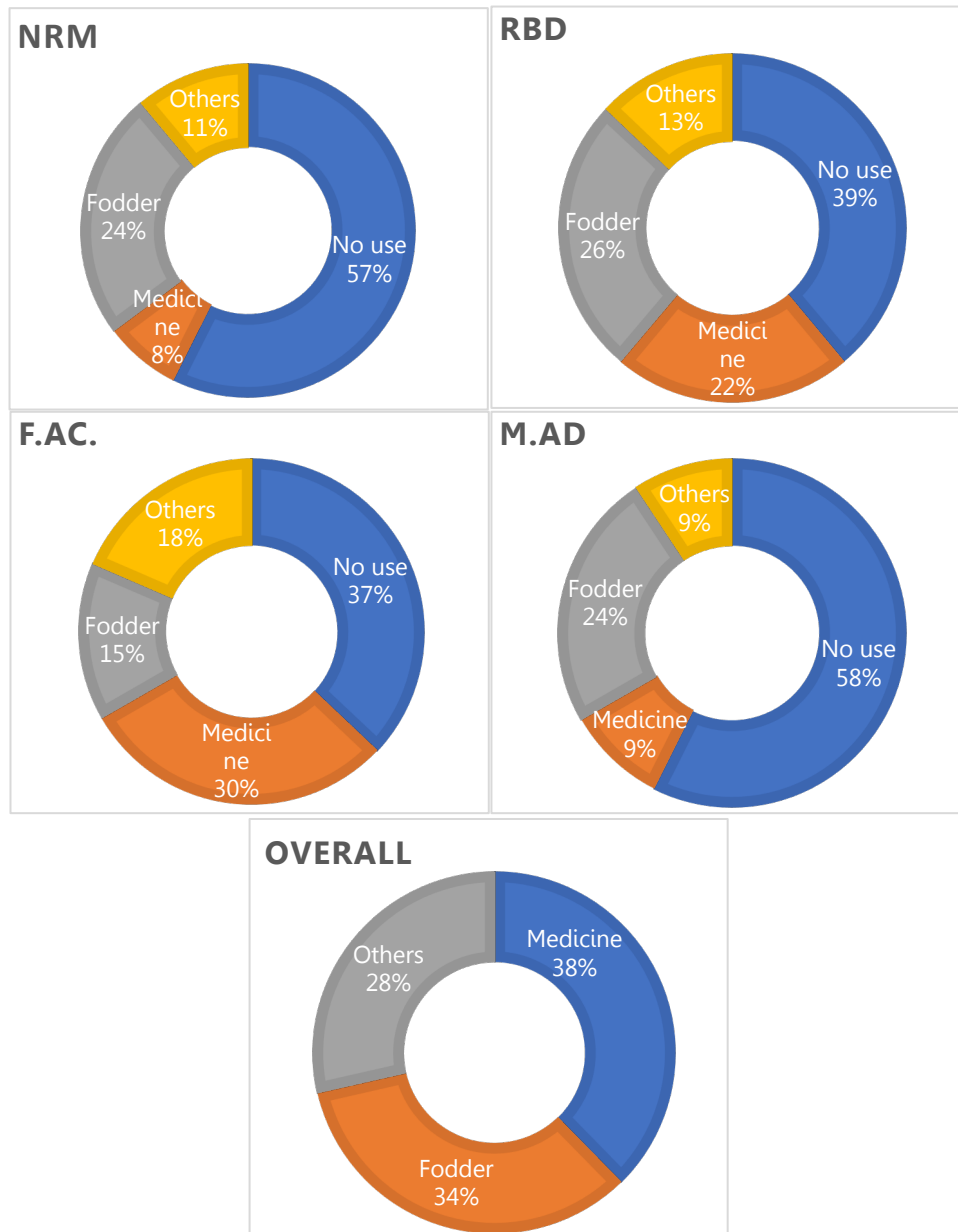


Figure 3. Distribution of ethnobotanical uses of the plants in and around the spring rice fields by different key informants

Based on IVI/summed dominance ratio (SDR), the plant species that predominate the spring rice fields were *Spirodela polyrrhiza* (L.) Schleid. (42.7 IVI/ 14.23 SDR), *Cyperus difformis* L. (32.1 IVI/ 10.69 SDR), *Azolla* Lam. (31.7 IVI/ 10.55 SDR), *Lindernia procumbens* (Krock.) Philcox (23.8 IVI/ 7.92 SDR), *Mecardonia procumbens* (Mill.) Small (12.7 IVI/ 4.219 SDR), *Fimbristylis quinquangularis* (Vahl) Kunth (11.6 IVI/ 3.876 SDR) (Annex B). Among them, *Cyperus difformis* L. and *Lindernia procumbens* (Krock.) Philcox were also reported in the paddy fields in Far-western Nepal. Besides, *Alternanthera sessilis* (L.) R.Br. ex DC., *Cynodon dactylon* (L.) Pers., *Echinochloa colona* (L.) Link, *Eclipta prostrata* (L.) L., *Eleocharis atropurpurea* (Retz.) J. Presl & C. Presl, *Gratiola oppositifolia* L. ex Willd. (syn. *Lindernia oppositifolia* (L.) Mukerjee), and *Lindernia procumbens* (Krock.) Philcox are also the weeds reported in the paddy fields in Nepal affecting paddy yield (Manandhar *et al.* 2007; Bhatt *et al.* 2021).

Mecardonia procumbens (Mill.) Small, *Alternanthera sessilis* (L.) R.Br. ex DC., *Paspalum distihum* L., and *Ageratum houstonianum* Mill., which have relatively higher IVI/SDR, are reported as "introduced (alien) and invasive alien species" to Nepal. Besides, other seven species also fall under the list of 183 "introduced (alien) and invasive alien species," namely, *Schoenoplectiella supina* (L.) Lye; *Amaranthus spinosus* L.; *Eclipta prostrata* (L.) L.; *Ludwigia hyssopifolia* (G.Don.) Exell; *Chenopodium album* L.; *Scoparia dulcis* L.; *Senna tora* (L.) Roxb. (Shrestha *et al.* 2020).

All these eleven invasive species have no evidence of impact except *Ageratum houstonianum* Mill (GBIF Secretariat 2021). *Ageratum houstonianum* Mill is considered as highly problematic, resulting in several negative impacts on livelihoods of people, putting pressure on agriculture production, and forest regeneration. Moreover, there will be +70% increase in suitable habitat for *Ageratum houstonianum* Mill for the period 2050 with respect to current climate, further aggravating the negative impacts in the future (Shrestha *et al.* 2018).

Ethnobotanical uses

Among the 53 species of the spring rice field weeds, 33 have ethnobotanical values for different ethnic/caste groups predominant in Chitwan (i.e., Tharu, Darai, and Brahmin). In addition, 21 species found around the spring rice fields also have ethnobotanical values. These 54 species of weeds can be either used for medicine, fodder, vegetables, fruits, pickles, or ornamental purposes. A few can also be used as Marcha (for making wine) and coffee (*Senna tora* (L.) Roxb.). Seven species are designated as poisonous (Annex B). Three species have religious importance and are necessary for rituals (Annex B).

RBD and F.Ac reported a relatively higher proportion of ethnobotanical uses. Both reported the ethnobotanical uses of around 62% of the subject plants. The proportion is relatively less for NRM (43%) and M.Ad. (42%). F.Ac. reported the medicinal value of around 30% of the plants (Figure 3). Overlapping the responses from all four key stakeholders suggests that all these plant species have some ethnobotanical values. Around 38% of the plant species (i.e., 29 plant species) have medicinal value, 34% of the plant species serve as fodder, and the remaining 28% have other uses such as vegetables, fruits, poisons, ritual, ornamental, pickles, and Marcha.

Higher professional involvement, namely, Vaidyas, resulted in greater practical plant knowledge compared to others utilizing plant resources as per need only. This suggests that practical ethnobotanical knowledge among different ethnic/caste groups does not differ substantially. What makes a difference is the continuous practice/use of the plant resources for different purposes. Hence, it is not necessary that the ethnic groups have wider knowledge in the ethnobotanical uses of the weeds reported in spring rice fields and nearby.

Out of the 29 plant species having ethnomedicine use, medicinal uses of 16 plant species are reported in previous literature (please refer to Annex C). Some of the common medicinal values include skin-related problems such as cuts, burns, and scabies, followed by respiratory problems such as cough and asthma. As a low-lying district, Chitwan is hot in the summer. *Centella asiatica* (L.) Urb., *Hydrocotyle sibthorpioides* Lam., *Spirodela polyrrhiza* (L.) Schleid., and *Fagopyrum esculentum* Moench are useful in overcoming heatstroke. Similar, ethnomedicine use was also reported by Singh *et al.* (2014), Bhatta and Kunwar (2020), and Pageni *et al.* (2020). These species are also used to treat fever, including typhoid (Pradhan *et al.* 2020; Hazarika *et al.* 2021). *Juncus prismatocarpus* R.Br. and *Sphaeranthus indicus* L. are used for treating snake bites, whereas *Monochoria vaginalis* (Brum.f.) C. Presl and *Monochoria hastata* (L.) Solms. are used against cat/dog/tiger/jackal bites or scarring. Such ethnomedicine uses however were difficult to trace in earlier literature. This suggests that the key informants, who are also the prominent healers or Vaidyas or Guruwas in the locality, have been using many of the weeds in their local spring rice fields to treat various diseases. The key informants were using plant species for gastritis (*Mazus pumilus* (Burm.f.) Steenis; and *Phyllanthus urinaria* L.), eye related problems (*Helichrysum indicum* (L.) Grierson; and *Polygonum plebeium* R.Br), and arthritis (*Commelina diffusa* Burm.f.).

The informants were aware of the plants' habitat and worried that farmers consider these species useless or harmful plants in their spring rice fields. The new generation's decreasing interest in farming and use of the plant resources for day-to-day life, including medicinal uses, remain the critical concerns raised by all the key informants. This was also the case reported in several other similar studies in Nepal (Bhatt *et al.* 2021).

Conclusion

In the present study, 53 weed species belonging to 43 genera and 22 families were reported in the spring rice fields, while 21 others were also found in the fields' vicinity during the same season. Of the total 75 species, 54 species bear ethnobotanical values. Most of the weeds have value as medicine or fodder (i.e., 29 species medicinal and 26 fodder). Among these, six species have both medicinal and fodder value.

People of the Tharu settlement in Bangain and the Darai settlement in Mangalpur (close to IAAS farm) rely on different plant resources as the first resort for health aid. They go to a pharmacy only if the recommendations of Guruwas/Vaidyas do not work. They visit a doctor as the secondary resort. The Brahmin settlements of Champanagar and Ujjalnagar are similar. Hence, documentation of weeds' ethnobotanical uses will serve as

valuable information for efficient use of plant resources regarded as “harmful” for main crops and, therefore, “unwanted.” Moreover, the increased urbanization rate in the study areas is causing loss of agricultural land threatening not only farming, but also the ethnobotanical uses of weed species prominent in those farmlands. Thus, this study’s main contribution includes documenting these ethnobotanical uses of weed species. Under the context of decreasing interest in use of plant resources for day-to-day life, this documentation will be a valuable resource for efficient management of harmful and unwanted plants, i.e., weeds. Besides, there is also a need to inform people regarding the beneficial uses of the plants, including weeds, available in their vicinity, and make such documented information readily available to the people.

The author acknowledges the age of data used to prepare this manuscript; in particular, the ecological data concerning weeds may differ from the present, primarily due to changes in land-use.

Declarations

List of Abbreviation: Not applicable

Ethics approval and consent to participate: A verbal consent to do the ecological surveys were obtained from the spring rice field owners. Similarly, key informants verbally agreed to participate in the survey and disclose their names in the any kind of publication.

Consent for publication: Not applicable.

Availability of data and materials: All relevant data are within the manuscript.

Competing interests: The author declares there is not competing interests.

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Author’s contributions: The author conceptualized, implemented, analyzed, and written the manuscript.

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Annex A. Ecological data on weeds of spring rice at IAAS and its vicinity in Chitwan. (D = Density, A= Abundance, F% = Frequency, RD = Relative Density, RA = Relative Abundance, RF = Relative Frequency, IVI = Importance Value index, SDR = Summed Dominance Ratio)

Botanical name	Family	D	A	F%	RD	RA	RF	IVI	SDR
<i>Spirodela polyrrhiza</i> (L.) Schleid.	Araceae	227.4	454.8	50	19.55	20.2	2.959	42.7	14.23
<i>Cyperus difformis</i> L.	Cyperaceae	200.7	200.7	100	17.25	8.91	5.917	32.1	10.69
<i>Azolla</i> Lam.	Salviniaceae	164.2	328.4	50	14.12	14.6	2.959	31.7	10.55
<i>Lindernia procumbens</i> (Krock.) Philcox	Linderniaceae	136.9	136.90	100	11.77	6.08	5.917	23.8	7.921
<i>Mecardonia procumbens</i> (Mill.) Small	Plantaginaceae	55.5	111.00	50	4.771	4.93	2.959	12.7	4.219
<i>Fimbristylis quinquangularis</i> (Vahl) Kunth	Cyperaceae	43.8	43.8	100	3.765	1.94	5.917	11.6	3.876
<i>Alternanthera sessilis</i> (L.) R.Br. ex DC.	Amaranthaceae	31.7	1.7	100	2.725	1.41	5.917	10.0	3.35
<i>Paspalum distichum</i> L.	Poaceae	36.1	72.2	50	3.104	3.2	2.959	9.3	3.089
<i>Lindernia anagallis</i> (Brum.f.) Pennell	Linderniaceae	16.3	163.00	10	1.401	7.23	0.592	9.2	3.076
<i>Ageratum houstonianum</i> Mill.	Compositae	32.1	80.25	40	2.76	3.56	2.367	8.69	2.896
<i>Eleocharis atropurpurea</i> (Retz.) J.Presl & C.Presl	Cyperaceae	28.6	71.5	40	2.459	3.17	2.367	8.0	2.666
<i>Gratiola oppositifolia</i> L. ex Willd.	Linderniaceae	24.3	34.71	70	2.089	1.54	4.142	7.77	2.591
<i>Cyperus rotundus</i> L.	Cyperaceae	25.1	50.2	50	2.158	2.23	2.959	7.34	2.448
<i>Fimbristylis</i> Vahl	Cyperaceae	21.6	36.0	60	1.857	1.6	3.55	7.01	2.335
<i>Digitaria ciliaris</i> (Retz.) Koeler	Poaceae	23.0	46.0	50	1.977	2.04	2.959	6.98	2.326
<i>Echinochloa colona</i> (L.) Link	Poaceae	20.5	41.0	50	1.762	1.82	2.959	6.54	2.18
<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	15.5	31.00	50	1.333	1.38	2.959	5.67	1.889
<i>Cyperus iria</i> L.	Cyperaceae	9.5	95.0	10	0.817	4.22	0.592	5.63	1.875
<i>Polycarpon prostratum</i> (Forssk.) Asch. & Schweinf.	Caryophyllaceae	6.3	21.0	30	0.542	0.93	1.775	3.25	1.083
<i>Commelina diffusa</i> Burm.f.	Commelinaceae	4.3	10.75	40	0.37	0.48	2.367	3.21	1.071
<i>Schoenoplectiella supina</i> (L.) Lye	Cyperaceae	5.4	18.0	30	0.464	0.8	1.775	3.04	1.013
<i>Monochoria vaginalis</i> (Brum.f.) C. Presl	Pontederiaceae	2.1	5.25	40	0.181	0.23	2.367	2.78	0.927
<i>Limnophila indica</i> (L.) Druce	Plantaginaceae	3.5	1.67	30	0.301	0.52	1.775	2.59	0.865
<i>Amaranthus spinosus</i> L.	Amaranthaceae	1.0	2.5	40	0.086	0.11	2.367	2.56	0.855
<i>Mollugo pentaphylla</i> L.	Molluginaceae	1.6	5.33	30	0.138	0.24	1.775	2.15	0.716
<i>Helichrysum indicum</i> (L.) Grierson	Compositae	1.4	4.66	30	0.12	0.21	1.775	2.10	0.701
<i>Eclipta prostrata</i> (L.) L.	Compositae	0.9	3.0	30	0.077	0.13	1.775	1.99	0.662
<i>Rotala rotundifolia</i> (Buch.-Ham. ex Roxb.) Koehne	Lythraceae	2.6	13.0	20	0.224	0.58	1.183	1.98	0.661
<i>Microcarpaea minima</i> (K.D.Koenig ex Retz.) Merr.	Plantaginaceae	2.2	11.00	20	0.189	0.49	1.183	1.86	0.62
<i>Hedyotis</i> L.	Rubiaceae	1.8	9.00	20	0.155	0.4	1.183	1.74	0.579
<i>Lindernia parviflora</i> (Roxb.) Haines	Linderniaceae	1.1	5.5	20	0.095	0.24	1.183	1.52	0.507

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<i>Cyperus compressus</i> L.	Cyperaceae	0.8	4.0	20	0.069	0.18	1.183	1.43	0.477
<i>Schoenoplectiella erecta</i> (Poir.) Lye	Cyperaceae	1.4	14.0	10	0.12	0.62	0.592	1.33	0.444
<i>Ludwigia hyssopifolia</i> (G.Don.) Exell	Onagraceae	0.4	0.4	20	0.034	0.09	1.183	1.31	0.436
<i>Chenopodium album</i> L.	Amaranthaceae	0.3	1.5	20	0.026	0.07	1.183	1.28	0.425
<i>Juncus prismatocarpus</i> R.Br.	Juncaceae	1.0	10.0	10	0.086	0.44	0.592	1.12	0.374
<i>Fimbristylis dichotoma</i> (L.) Vahl	Cyperaceae	0.8	8.0	10	0.069	0.36	0.592	1.02	0.339
<i>Cyperus</i> L.	Cyperaceae	0.7	7.0	10	0.60	0.31	0.592	0.96	0.321
<i>Scoparia dulcis</i> L.	Plantaginaceae	0.6	6.00	10	0.052	0.27	0.592	0.91	0.303
<i>Cyperus tenuiculmis</i> Boeckeler	Cyperaceae	0.5	5.0	10	0.043	0.22	0.592	0.86	0.286
<i>Mazus pumilus</i> (Burm.f.) Steenis	Phrymaceae	0.5	5.00	10	0.043	0.22	0.592	0.86	0.286
<i>Fagopyrum esculentum</i> Moench	Polygonaceae	0.3	3.0	10	0.026	0.13	0.592	0.75	0.25
<i>Persicaria barbata</i> (L.) H.Hara	Polygonaceae	0.3	3.00	10	0.026	0.13	0.592	0.75	0.25
<i>Centella asiatica</i> (L.) Urb.	Apiaceae	0.1	1.0	10	0.009	0.04	0.592	0.64	0.215
<i>Hydrocotyle sibthorpioides</i> Lam.	Araliaceae	0.1	1.0	10	0.009	0.04	0.592	0.64	0.215
<i>Centipeda minima</i> (L.) A.Braun & Asch.	Compositae	0.1	1.0	10	0.009	0.04	0.592	0.64	0.215
<i>Acmella paniculata</i> (Wall. ex DC.) R. K. Jansen	Compositae	0.1	1.0	10	0.009	0.04	0.592	0.64	0.215
<i>Senna tora</i> (L.) Roxb.	Fabaceae	0.1	1.0	10	0.009	0.04	0.592	0.64	0.215
<i>Desmodium triflorum</i> (L.) DC.	Fabaceae	0.1	1.0	10	0.009	0.04	0.592	0.64	0.215
<i>Pisum sativum</i> L.	Fabaceae	0.1	1.0	10	0.009	0.04	0.592	0.64	0.215
<i>Vicia sativa subsp. nigra</i> (L.) Ehrh.	Fabaceae	0.1	1.0	10	0.009	0.04	0.592	0.64	0.215
<i>Rotala indica</i> (Willd.) Koehne	Lythraceae	0.1	1.0	10	0.009	0.04	0.592	0.64	0.215
<i>Phyla nodiflora</i> (L.) Greene	Verbenaceae	0.1	1.00	10	0.009	0.04	0.592	0.64	0.215

Annex B. Ethnobotanical value of weeds found in and around the spring rice fields. (Th = Tharu, M = Medicine, V = Vegetables, R = Religious, Pi = Pickle, D = Darai, Po = Poison, Fr = Fruit, Or = Ornamental, Bh = Brahmin, F = Fodder, Ma = Marcha)

Botanical name	Local name	Family	NRM	RBD	F.Ac.	M.Ad
<i>Alternanthera sessilis</i> (L.) R.Br. ex DC. *	Chimke jhar (Bh)	Amaranthaceae	-	-	F/M	-
<i>Amaranthus spinosus</i> L. *	Lunde (Bh), kataiya (Th)	Amaranthaceae	-	-	V	M/V
<i>Chenopodium album</i> L. *	Bethe (Bh), bethua (D\Th)	Amaranthaceae	V	V	V	V
<i>Centella asiatica</i> (L.) Urb. *	Ghode tapre (Bh), ghortapua (Th)	Apiaceae	M	M	-	M
<i>Hydrocotyle sibthorpioides</i> Lam. *	Sano amili chari jhar (Bh), pothi ghode tapre (D), tarpurin (Th)	Araliaceae	F	F/M	F	F
<i>Spirodela polyrrhiza</i> (L.) Schleid. *	Ghole tapre (Bh), surabir (D)	Araceae	-	M	M	-
<i>Ageratum houstonianum</i> Mill. *	Bokeban (D), dandhe jhar/jhangi (Bh/Th)	Compositae	M/Po	M	-	-
<i>Eclipta prostrata</i> (L.) L. *	Bhringaraj (Bh), bhugurna (Th)	Compositae	M	-	-	M
<i>Helichrysum indicum</i> (L.) Grierson *	Buke jhangi (D), buke phool (Bh), darangi (Th)	Compositae	-	M	-	F
<i>Acmella paniculata</i> (Wall. ex DC.) R. K. Jansen *	Tite jhar (Bh), bador-kador (D), rudhilo (Bh)	Compositae	-	Fr	M	-
<i>Polycarpon prostratum</i> (Frossk.) Asch. & Schweinf. *	Chimke jhar (Bh), bhebhurna (D)	Caryophyllaceae	-	M	F/M	-
<i>Commelina diffusa</i> Burm.f. *	Kane jhangi/jhar (D/Bh), gerguj (Th)	Commelinaceae	-	F	M	F
<i>Cyperus compressus</i> L. *	Chiure jhar (Bh)	Cyperaceae	-	-	-	F
<i>Cyperus difformis</i> L. *	Sano mothe (Bh), mothe (D/Th)	Cyperaceae	F	F	F	F
<i>Cyperus tenuiculmis</i> Boeckeler *	Thulo mothe (Bh), pani mothe (D) dhabbwala mothe (Bh)	Cyperaceae	-	F	F	-
<i>Eleocharis atropurpurea</i> (Retz.) J.Presl & C.Presl *	Fuli jhar/Chandani jhar (Bh)	Cyperaceae	-	-	Or	Or
<i>Fimbristylis quinquangularis</i> (Vahl) Kunth *	Thulo jwane jhar/jhangi (Bh/D), jhusuna (Th)	Cyperaceae	-	F/M	-	-
<i>Fimbristylis</i> Vahl *	Kharra jwane sama (Bh), bhend raunwa (D)	Cyperaceae	-	F	M	-
<i>Schoenoplectiella supina</i> (L.) Lye *	Suire jhar (Bh), sosa (Th), suri (D)	Cyperaceae	F	M	-	F
<i>Senna tora</i> (L.) Roxb. *	Tapre (Bh/D), chakror (Th)	Fabaceae	-	F	Coffee	-
<i>Pisum sativum</i> L. *	Jangalikerau (D), chimtakerau (Th)	Fabaceae	-	Pi/Fr	-	-
<i>Juncus prismatocarpus</i> R.Br. *	Tauke jhar (Bh)	Juncaceae	-	-	M/Po	-
<i>Lindernia anagallis</i> (Brum.f.) Pennell *	Kanchi saag (Bh)	Linderniaceae	-	-	-	V
<i>Gratiola oppositifolia</i> L. ex Willd.	Chimke jhar/ jiliot pati (Bh), harhatch saag (Th)	Linderniaceae	V	F/M	-	-
<i>Rotala rotundifolia</i> (Buch.-Ham. ex Roxb.) Koehne *	Runia (Bh)	Lythraceae	-	-	M	-
<i>Mazus pumilus</i> (Burm.f.) Steenis *	Chini jhar (Bh)	Phrymaceae	-	-	M	-
<i>Cynodon dactylon</i> (L.) Pers. *	Dubo (D/Th), sano dubo (Bh)	Poaceae	R	R	-	F/M/R

<i>Digitaria ciliaris</i> (Retz.) Koeler *	Jhuse jhanggi (D)	Poaceae	-	F	-	-
<i>Echinochloa colonum</i> (L.) Link. *	Sama banso (Bh), sama (Th), pani sama (D)	Poaceae	F	-	-	F
<i>Paspalum distichum</i> L. *	Pani kane (D), suiri ghaans (Th)	Poaceae	F	F	-	-
<i>Fagopyrum esculentum</i> Moench *	Faper (D)	Polygonaceae	-	M	-	-
<i>Persicaria barbata</i> (L.) H.Hara *	Purre jhar (Bh), totera (Th), blesendhari (D)	Polygonaceae	Po	M	M	Po
<i>Monochoria vaginalis</i> (Brum.f.) C. Presl *	Baans pate (Th), tarpurain (D)	Pontederaceae	F	-	M	-
<i>Caesulia axillaris</i> Roxb. **	Khotila jhanggi (Th), kumale jhar (Bh)	Compositae	-	-	Po	-
<i>Laphangium luteoalbum</i> (L.) Tzvelev **	Buke phool (Bh), phohori (Th)	Compositae	Po	-	-	-
<i>Sphaeranthus indicus</i> L. **	Tauke jhar (Bh), khattesari (Th), Jangali marahathi jhanggi (D)	Compositae	-	M	M/Po	-
<i>Xanthium strumarium</i> L. **	Bhende kuro / madeshe kuro (Bh), Chidchidia/ khanger (Th), khangro (D)	Compositae	-	-	M	-
<i>Cleome viscosa</i> L. **	Bantori (Bh)	Cleomaceae	-	Ma	Po/Ma	-
<i>Ipomoea aquatica</i> Forssk. **	Ajambari jhar (Bh), farmaiya (Th), karami (D)	Convolvulaceae	-	V	V	M/V
<i>Euphorbia hirta</i> L. **	Tika jhanggi (Th), dudhe jhar (Bh), rani dubo (D)	Euphorbiaceae	M	-	-	-
<i>Salvia plebeia</i> R.Br. **	Halhale (Bh), jhuse jhanggi (D)	Lamiaceae	-	-	V	-
<i>Phyllanthus urinaria</i> L. **	Bhiun amala (Bh), amita (Th)	Phyllanthaceae	F	-	M	-
<i>Echinochloa crus-galli</i> (L.) P. Beauv. **	Kathe sama (Bh), paterigandir (D)	Poaceae	-	F	R	F/R
<i>Eleusine indica</i> (L.) Gaertn. **	Kode jhar (Bh), dande jhanggi (D)	Poaceae	F	F	F	F
<i>Eragrostis gangetica</i> (Roxb.) Steud. **	Ghobe banso (Bh), bhote dubo (D), chari dana (Th)	Poaceae	F	F	-	-
<i>Hemarthria compressa</i> (L.f.) R. Br. **	Ghode dubo (Bh), gandir (D/Th)	Poaceae	F	F	F	F
<i>Isachne globosa</i> (Thunb.) Kuntze **	Sano banso (Bh), sano ghode dubo (Bh), sora (Th)	Poaceae	-	-	F	F
<i>Leersia hexandra</i> Sw. **	Karaunte jhar (Bh), chalen (D/Th), madeshe jhar (Bh),	Poaceae	F	F	R	R
<i>Paspalum dilatatum</i> Poir. **	Kode ghaans (Bh), mane jhanggi (D), sawa (Th)	Poaceae	F	F	F	F
<i>Setaria pumila</i> (Poir.) Roem. & Schult. **	Bale banso (Bh), kagune banso (Bh), bander puchre (D/Th)	Poaceae	F	F	F	F
<i>Persicaria lanigera</i> (R.Br.) Soják **	Totaban (D), totayar (Th)	Polygonaceae	-	Or	-	-
<i>Polygonum plebeium</i> R.Br. **	Sukul jhar (Bh), gogainri jhanggi (D)	Polygonaceae	-	-	M	-
<i>Monochoria hastata</i> (L.) Solms **	Pate karkalo (Bh), pipal pate (Bh), chindhodaya (Th), pani karkalo(D)	Pontederiaceae	-	-	M	-
<i>Solanum americanum</i> Mill. **	Kali gedi (Th)	Solanaceae	V	-	-	-

Notes: * species found in the spring rice fields and ** species found around the spring rice fields.

Annex C. Medicinal uses of weeds found in and around the spring rice fields

Family	Species	Local name	Methods of use	Medicinal value	Uses in earlier references
Amaranthaceae	<i>Alternanthera sessilis</i> (L.) R.Br. ex DC. *	Chimke jhar	Plant juice except root	Cold and cough	Piles, abortion, and increasing energy (Yabesh <i>et al.</i> 2014); Asthma, pneumonia, and bronchitis (Arunesh <i>et al.</i> 2018; Swapna <i>et al.</i> 2011); Wounds, venereal disease, and menstrual disorder (Bhatt & Kunwar 2020; Bhatt <i>et al.</i> 2021)
Amaranthaceae	<i>Amaranthus spinosus</i> L. *	Lunde	Matured plant juice	Regulation in urination	Skin allergy (Yabesh <i>et al.</i> 2014); Diarrhea (Arunesh <i>et al.</i> 2018; Bhatt <i>et al.</i> 2021); Toothache, eczema, and urinary troubles (Arunesh <i>et al.</i> 2018); Cough, common cold, and dizziness (Pangeni <i>et al.</i> 2020); Internal bleeding, excessive menstruation, snake bites, boils, stomach disorders, mouth ulcers, and gonorrhoea (Bhatt <i>et al.</i> 2021)
Apiaceae	<i>Centella asiatica</i> (L.) Urb. *	Ghod tapre	Leaf juice	Typhoid, fever, urinary disorder, heatstroke (Garmigadeko), treatment for alcoholic tipsiness	Memory power (Anuresh <i>et al.</i> 2018; Swapna <i>et al.</i>

					<p>2011; Yabesh <i>et al.</i> 2014); Headache (Bhatt <i>et al.</i> 2021; Bhatt & Kunwar 2020; Yabesh <i>et al.</i> 2014); Fever, sore throat (Pradhan <i>et al.</i> 2020); Stomachache, indigestion (Pangeni <i>et al.</i> 2020; Pradhan <i>et al.</i> 2020; Yabesh <i>et al.</i> 2014); Skin disease (Bhatt <i>et al.</i> 2021; Bhatt & Kunwar 2020; Pradhan <i>et al.</i> 2020; Singh <i>et al.</i> 2014; Swapna <i>et al.</i> 2011); Tonic (Bhatt & Kunwar 2020; Singh <i>et al.</i> 2014); Wound healing (Pradhan <i>et al.</i> 2020; Anuresh <i>et al.</i> 2018); Atherosclerosis (Anuresh <i>et al.</i> 2018); Urinary troubles (Bhatt <i>et al.</i> 2021; Bhatt & Kunwar 2020; Pradhan <i>et al.</i> 2020); Asthma (Anuresh <i>et al.</i> 2018; Pangeni <i>et al.</i> 2020; Swapna <i>et al.</i> 2011); Heat stroke and gastritis (Pangeni <i>et al.</i> 2020)</p>
Araliaceae	<i>Hydrocotyle sibthorpioides</i> Lam. *	Pothi ghode tapre	Leaf juice	Fever, urinary disorder, cold,	Fever, edema, dysentery, rheumatagia, whooping

				heatstroke (Garmigadeko), treatment for alcoholic tipsiness	cough, jaundice, throat pain, psoriasis, herpes zoster infection, hepatitis-B infection, soothing pain, dysmenorrhea, carbuncle, brain tonic, detoxifying agent, and hepatoprotective agent (Hazarika <i>et al.</i> 2021)
Compositae	<i>Ageratum houstonianum</i> Mill. *	Dandhe jhangi	Plant Juice	Cuts (to clot blood)	Antifungal, antimicrobial, and insecticidal properties (cited in Tennyson <i>et al.</i> 2012)
Compositae	<i>Eclipta prostrata</i> (L.) L. *	Bhringaraj	Plant juice/Tender leaves as vegetables	Wounds due to mud, pimples, sexually transmitted diseases (Yoni rog) / Night blindness	Reduce body heat (Yabesh <i>et al.</i> 2014); Headache and hair growth (Yabesh <i>et al.</i> 2014; Swapna <i>et al.</i> 2011); Cut wounds, skin diseases and pimples, night blindness and jaundice (Bhatt & Kunwar 2020); Dysentery (Pangeni <i>et al.</i> 2020); Snake bite, antibacterial, and antioxidant (Bhatt <i>et al.</i> 2021); Ulcer, tonic, deobstruent in hepatic and spleen enlargement, skin diseases, catarrhal jaundice, catarrhal in

					infants, toothache, eczema, and relief of pain from scorpion sting (Swapna <i>et al.</i> 2011)
Compositae	<i>Helichrysum indicum</i> (L.) Grierson *	Buke phool	Plant juice	Cuts (to clot blood)	
Compositae	<i>Acmella paniculata</i> (Wall. ex DC.) R. K. Jansen *	Rudhilo	Plant juice, crush leaves	Burns (boil), wounds	
Caryophyllaceae	<i>Polycarpon prostratum</i> (Frossk.) Asch. & Schweinf. *	Chimke jhar	Plant juice except root	Wounds caused by mud	
Commelinaceae	<i>Commelina diffusa</i> Burm.f. *	Kane jhangi	Rhizome paste	Rheumatism (Aankhle)	Burns, itches, and boils (Swapna <i>et al.</i> 2011)
Cyperaceae	<i>Fimbristylis quinquangularis</i> (Vahl) Kunth *	Thulo jwane jhangi	Seed + Bark of Saaj (<i>Terminalia elliptica</i> Willd.)	Whooping cough	Fever (Tajkia <i>et al.</i> 2018)
Cyperaceae	<i>Fimbristylis</i> Vahl *	Kharra jwone sama	Boiled seed in water	Headache	
Cyperaceae	<i>Schoenoplectiella supina</i> (L.) Lye *	Suri	Rhizome juice	Fever in pregnant woman	
Juncaceae	<i>Juncus prismatocarpus</i> R.Br. *	Tauke jhar	Leaf juice	Snake bite	
Araceae	<i>Spirodela polyrrhiza</i> (L.) Schleid.*	Ghol tapre	Leaf juice	Typhoid, fever, urinary disorder, heatstroke (Garmigadeko), treatment for alcoholic tipsiness	
Lythraceae	<i>Rotala rotundifolia</i> (Buch.-Ham. ex Roxb.) Koehne*	Runia	Tender leaves juice	Chest pain, asthma	Cough, cold, and fever (Swapna <i>et al.</i> 2011)
Poaceae	<i>Cynodon dactylon</i> (L.) Pers. *	Duboo	Plant juice/Plant juice + Lemon juice	Cuts (to stop bleeding)/ Fracture (Massage)	Blood purifier (Amjad <i>et al.</i> 2015; Bhatt <i>et al.</i> 2021; Yabesh <i>et al.</i> 2014); Control nosebleed, stop bleeding, and as topical anti-septic (Amjad <i>et al.</i> 2015; Bhatt <i>et al.</i> 2021); gastritis (Yabesh <i>et al.</i> 2014);

					Vomiting (Bhatt <i>et al.</i> 2021; Singh <i>et al.</i> 2014); Jaundice, diuretic (Singh <i>et al.</i> 2014); Leukoderma, bronchitis, piles, asthma, tumors, skin diseases (Arunesh <i>et al.</i> 2018); Fever (Budha-Magar <i>et al.</i> 2020); Fractures (Bhatt & Kunwar 2020); Cuts and wounds (Bhatt & Kunwar 2020; Pradhan <i>et al.</i> 2020); Urinary and bladder complaints (Pradhan <i>et al.</i> 2020); Anti-diabetic effect (Bhatt <i>et al.</i> 2021)
Polygonaceae	<i>Fagopyrum esculentum</i> Moench *	Faper	Plant	Mouth ulcers (Kufat), heat sensation (Aantjaleko)	Urinary disorder (Singh <i>et al.</i> 2014)
Polygonaceae	<i>Persicaria barbata</i> (L.) H.Hara *	Pirre jhar	Leaf juice + Rice flour	Green poop / diarrhea in 2-3 months old baby (prescribed to the mother)	Pains of colic, dysentery, cholera, scabies, and applied externally to wounds (Bhatt <i>et al.</i> 2021)
Pontederiaceae	<i>Monochoria vaginalis</i> (Brum.f.) C. Presl *	Bans pate	Milky latex	Cat, dog, tiger, jackal bite or scarring	
Linderniaceae	<i>Gratiola oppositifolia</i> L. ex Willd.	Chimke jhar	Plant juice except root	Cold and cough	Dysentery and intestinal problems (Bhatt <i>et al.</i> 2021; Bhatt & Kunwar 2020)
Phrymaceae	<i>Mazus pumilus</i> (Burm.f.) Steenis *	Chini jhar	Leaf and stem	Gastritis	

Compositae	<i>Sphaeranthus indicus</i> L. **	Tauke jhar	Leaf juice	Snake bite, chocking (Ghanti ma kehi aadkiyama)	
Compositae	<i>Xanthium strumarium</i> L. **	Bhende kuro	Fruit and Dhaturu	Mental disorder	Skin treatment, anti-inflammatory, and antibacterial properties (Bhatt <i>et al.</i> 2021)
Convolvulaceae	<i>Ipomoea aquatica</i> Forssk. **	Ajambari jhar	Young shoots/ leaves extract	Cure for diabetes/cough	
Euphorbiaceae	<i>Euphorbia hirta</i> L. **	Dudhe jhar	Plant	Paralysis	Asthma (Arunesh <i>et al.</i> 2018; Yabesh <i>et al.</i> 2014); Cough, snake bites, and lip cracks (Yabesh <i>et al.</i> 2014); Cancer, bronchial infections, abscesses (Arunesh <i>et al.</i> 2018); Wounds, skin diseases, and boils (Bhatt <i>et al.</i> 2021; Bhatt & Kunwar 2020)
Phyllanthaceae	<i>Phyllanthus urinaria</i> L. **	Bhuin amala	Plant juice	Gastritis and diarrhea	Diuretic and appetite stimulator (Bhatt <i>et al.</i> 2021; Bhatt & Kunwar 2020)
Pontederiaceae	<i>Monochoria hastata</i> (L.) Solms. **	Pipal pate	Milky latex	Cat, dog, tiger, jackal bite or scarring	
			Leaf juice	Scabies	
Polygonaceae	<i>Polygonum plebeium</i> R.Br. **	Sukul jhar	Plant juice	Eye swelling (Aankha ma phulo pareko)	

Note: * species found in the spring rice fields and ** species found around the spring rice fields.

