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Nutritional, Ethnomedicinal, and Agricultural Significance of Neglected and Underutilized Crops from Eastern Uttar Pradesh, North India

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Abstract: Meeting food and nutritional security needs for a growing population is a global sustainability challenge due to the heavy reliance on a few cultivated crops for dietary requirements across the world. To ensure local food security, it is imperative to diversify dietary options with locally available, neglected, and underutilized crops (NUCs) with nutritional and biocultural significance. In this context, the present study aims to explore the role of NUCs for nutritional, ethnomedicinal, and agricultural relevance in two districts of eastern Uttar Pradesh, i.e., Mirzapur and Sonebhadra. Extensive field surveys were conducted in the study sites, and a total of 445 local respondents were interviewed based on structured questionnaires for calculating ethnobotanical indices, i.e., relative frequency of citation (RFC), frequency of citation (FC), use report (UR), and cultural importance index (CI) of NUCs. The study identified 116 NUCs belonging to 55 families and 103 genera. All reported NUCs had medicinal value; 55 were edible and used as food; and 41 had agricultural significance. Leaves were the most commonly used plant parts for medicinal purposes, followed by roots and stems, whereas flowers were the least commonly used parts. NUCs were used by the locals for their medicinal properties to treat various ailments, such as skin and eye problems, headaches, and liver problems. They were administered as decoction, paste, vapor inhalation, fruit juice, and poultice. The RFC, FC, UR, and CI values of the NUCs were in the range of 12 to 365, 0.03 to 0.82, 12 to 394, and 0.03 to 0.89, respectively. Fruits were the most commonly consumed part, followed by leaves, tubers, pods, and aerial bulbs, whereas the mode of consumption was stir-fry, soup, vegetables, salad, or in raw form. NUCs were bestowed with essential macro- and micronutrients and were found in the range of Ca (3.79–1147.3), K (2.6–1600.3), Mg (0.8–468.0), Na (0.4–270.8), P (1.15–305), Fe (0.1–327.6), Zn (0.1–84.6), Cu (0.047–33.3), Mn (0.1–62.3) mg/100 g, and vitamins like ascorbic acid (0.04–1561.1), thiamine (0.041–2.4), and β-Carotene (0.2–93.6) mg/100 g. These NUCs were cultivated in different settings, such as kitchen gardens, backyard gardens, border crops, and sometimes agricultural fields. The current study reveals the rich diversity and varied use of these NUCs with respect to their ethnomedicinal, nutritional, and agricultural relevance. Sustainable utilization with large-scale cultivation of promising NUCs can lead to local food security and the subsequent attainment of the associated UN Sustainable Development Goals.

Keywords: neglected and underutilized crops; ethnobotany; food security; local and traditional knowledge

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1. Introduction

The global population currently exceeds 8 billion and is projected to surpass 11 billion by the end of this century. This substantial population growth has led to severe detrimental effects on the environment, including overexploitation of resources, pollution, unprecedented biodiversity loss, climate change, ecosystem degradation, and increasing global political unrest [1]. In 2021, approximately 2.3 billion people affected by moderate or severe

food insecurity due to limited access to nutritious and affordable food options [2]. Plants play a crucial role in ensuring human nutrition on a global scale, as they constitute around 84% of the human diet. However, there is a growing reliance on a limited number of crop species for food consumption. Out of the approximately 50,000 edible plant species known to humanity, only a small fraction, around 150 to 200 species, are utilized as food. Strikingly, a mere 15 crop plants provide 90% of the world's food energy intake, and more than 60 percent of this plant-based calorie intake comes from just three major crops, namely rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), and maize (*Zea mays* L.), resulting in an unfriendly food system for both people and the planet. Therefore, it is crucial to prioritize dietary diversification by incorporating locally available, nutritious, and climate-resilient neglected and underutilized crops (NUCs) to ensure food and nutritional security [2].

NUCs are wild or semi-domesticated crop species that tend to remain underexploited despite their immense potential. This category of plant species has great potential but has been largely overlooked in agricultural and food systems. The unique features of NUCs are that they are climate-resilient, low-input, nutritionally dense, and hardy crops that can even thrive in degraded ecosystems [3,4]. NUCs provide cost-effective nature-based solutions to various challenges, including biodiversity conservation, food security, preservation of local and traditional knowledge, income generation, and climate mitigation [5]. While they have been referred to as orphan crops, traditional crops, minor crops, and forgotten crops, they are now recognized as future smart crops, garnering attention from policymakers, scientists, and plant breeders as climate-adaptive, nutritious, and healthy food options that can help alleviate hidden hunger and malnutrition [3]. Utilizing NUCs in a prudent and sustainable manner can contribute to achieving several United Nations Sustainable Development Goals (UN-SDGs), including Goal 1 (No Poverty), Goal 2 (Zero Hunger), Goal 3 (Good Health and Well-being), Goal 12 (Responsible Consumption and Production), Goal 13 (Climate Action), and Goal 15 (Life on Land) [6].

WHO considers traditional medicine as the key component of primary healthcare. It defines traditional medicine as "*sum total of the knowledge, skill and practices based on the theories, beliefs and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health, as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness*". Around 80% of people in developing countries rely on local or traditional medicine for primary healthcare [7]. NUCs possess medicinal properties that can be used to treat various ailments, with approximately 30% of modern medicine or drugs derived from plants [8]. In addition to their medicinal and nutritional properties, these crops have multifaceted uses and can be cultivated on degraded lands, exhibiting better adaptation to local climates and ensuring sustained productivity and nutritional quality under changing climatic conditions [9]. Moreover, they are economically important with their low production cost, minimal external input requirements, short lifespan, and low risk, making them favorable for cultivation by rural women with small land holdings [10]. NUCs can further contribute to dietary diversification, diet supplementation, and food fortification, leading to better diet management and nutritional security, particularly in resource-deprived nations [11].

Uttar Pradesh, situated in the north-central part of India, has long been a thriving center of vibrant Indian culture. This region, known as the "rainbow land," is endowed with diverse geographical features and a multitude of cultural diversities. One particular area of interest is Eastern Uttar Pradesh, which exhibits unique characteristics that span from 23°51′ N to 28°30′ N and 81°31′ E to 84°39′ E, falling within the boundaries of Uttar Pradesh. Agriculture in this region predominantly relies on rainfall and is characterized by small and marginal land holdings, rendering it vulnerable to frequent flooding, droughts, and soil salinity. The principal cropping system revolves around rice and wheat. During the wet season (July–October), farmers cultivate rice, pigeon peas, mung beans, and maize, while the winter season (November–February) witnesses the growth of wheat, barley, chickpeas, peas, rapeseed, and mustard. Mirzapur and Sonbhadra, situated in eastern Uttar Pradesh, stand out for their remarkable biodiversity and agrobiodiversity. These

regions, nestled in the Gangetic Plain, boast a diverse range of ecosystems, including forests, wetlands, rivers, and agricultural landscapes. In terms of agrobiodiversity, Mirzapur and Sonbhadra possess fertile agricultural lands that make significant contributions to Uttar Pradesh's overall agricultural output. However, the region also faces challenges related to biodiversity conservation and sustainable agriculture due to deforestation, habitat degradation, industrialization, and unsustainable agri-management [12,13].

Hence, in order to tackle these challenges, the present study was undertaken to examine the prevalence and utilization of neglected and underutilized crops (NUCs) in the Eastern Uttar Pradesh region, specifically focusing on the districts of Mirzapur and Sonebhadra. The major objectives of this study were as follows: (i) to conduct an inventory of NUCs in the selected area; (ii) to explore the ethnomedical applications and modes of preparation and applications of NUCs; and (iii) to gain insights into the nutritional and agricultural characteristics of the identified NUCs. Moreover, this study can serve as a foundational investigation for similar inventory studies and in-depth analyses of NUCs, shedding light on their role in ensuring food and nutritional security as well as enhancing the livelihoods and incomes of the population dependent on NUCs.

2. Materials and Methods

2.1. Description of the Study Area

The field survey was conducted in the Mirzapur and Sonebhadra districts of eastern Uttar Pradesh, which are situated between the latitudes and longitudes of 25.1337° N by 82.5644° E and 24.4570° N by 82.9932° E, as shown in Figure 1. The average annual temperatures in Mirzapur and Sonebhadra are 26.0 °C and 24.9 °C, while the annual average precipitation in the districts is 964 mm and 1115 mm, respectively. The study area falls under the Vindhyachal agro-climatic zone, with most of the area being rocky and undulated. In contrast, the plains have light black clay and red alluvial soil. Sonebhadra is home to around 1,862,559 people, while Mirzapur has a population of 2,496,970, with the majority residing in rural areas.

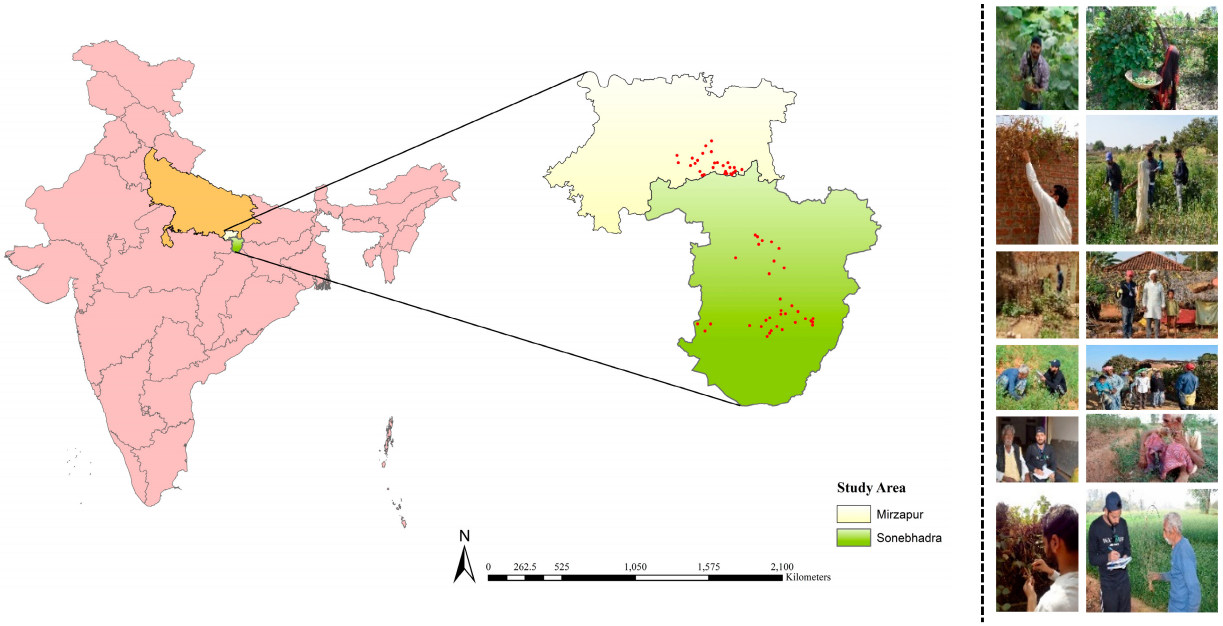

Figure 1. (**A**) The study area i.e., Mirzapur and Sonebhadra districts of Eastern Uttar Pradesh, North India, (**B**) Photographs depicting the interaction among the local people conducted during January 2018 to February 2020.

2.2. Demographic Information of Respondents

A multilayered periodic survey was conducted during the period of March 2018 and February 2020, involving interviews with a total of 445 local individuals. Specifically, 221 respondents were from Mirzapur, and 224 respondents were from Sonebhadra, representing a combined sample from 63 villages in the eastern Uttar Pradesh region. The respondent's age ranged from 21 to 65 years old. In Mirzapur district, 54% of the respondents were male and 46% were female. Similarly, in Sonebhadra district, the majority of respondents were male, accounting for 57%, while females accounted for approximately 43%. Table 1 contains comprehensive demographic information about the respondents and the regions covered during the survey period.

Table 1. Demographic details of the respondents from the surveyed region.

District	Village Covered	Respondents Detail		
		Gender	Age Group	Interviewed People
Mirzapur	Nadihar, Kon, Loosa, Dhansiriya, Sonbarsa, Rampur baraho, Lurkutia, Shemaran, Rampur, Piparwar, Sarso, Matihani, Nunauti, Bhawan, Karaunda, Raikari, Bagahi, Tendua, Khurd, Devari Kalan, Salaia, Etwa, Tedhwa, Dharura, Karkoll, Tekuria, Bishunpur, Garhawa, Jaugarh.	Male	21–30	54
			31–50	43
			>50	23
		Female	18–30	31
			31–50	29
			>50	41
Sonebhadra	Khajuri, Gosari, Pipari, Kharpathar, Labhari, Kuldomari, Auri, Garbandha, Rantola, Karaundhi, Katauli, Majhauli, Kadal, Dumhan, Redia, Raspahari, Khairahi, Kirawani, Murdhava, Saudih, Hathawani, Navgai, Dalapipar, Baheradol, Gardarwa, Birar, Baraidar, Jabar, Maldewa, Tilgudwa, Kota, Pakari, Markuri, Belach.	Male	21–30	42
			31–50	39
			>50	47
		Female	18–30	31
			31–50	36
			>50	29
				Total = 445

2.3. Data Collection

Prior to the interview, the informants were systematically briefed on the objectives and relevance of the current study, and prior informed consent (verbal approval) for documentation and reporting of traditional and local knowledge was obtained. The information regarding the uses of NUCs was collected based on a structured questionnaire with open-ended responses and focused group discussion. The information regarding the vernacular names of the NUCs with the use of the plant species was recorded and cross-referenced during the survey period with different respondents. Additionally, the NUCs were listed along with their medicinal importance and agricultural relevance based on the questionnaire. Local and traditional knowledge regarding the specific use of the plant for medical treatment, the mode of administration, as well as the ailments it treats, was recorded. Furthermore, the abundance of the species was recorded based on the responses and field observations. Information about the edible part and method of consumption of the edible NUCs was also recorded. The informants were also questioned about the relevance and use of such NUCs in the agricultural system. Nutritional data (minerals and vitamins) for the enlisted edible NUC species were collected from previously published scholarly articles from various databases, i.e., Google Scholar, ScienceDirect, Web of Science, Pubmed, and the FoodData Central dataset of the USDA. Voucher herbarium specimens were prepared for all species during the study period and submitted to the Department of Botany at Krishak P.G. College, Rajgarh, for future study. The accepted names were verified using the International Plant Names Index (IPNI) database [14].

2.4. Data Calculation

Quantitative ethnobotanical analyses were performed for the recorded NUCs using different indices such as frequency of citation (FC), relative frequency of citation (RFC), use category (number of respondents that mentioned a useful species in any of the three categories, i.e., food, medicine, and agriculture), use reports (UR), and cultural importance index (CI) [15,16]. The index frequency of citation refers to the number of informants mentioning the use of one species. This index is often used as a method for evaluating the cultural value of a certain species as well as its adaptability. The relative frequency of citation (RFC) refers to the proportion of respondents that indicate using one species [16].

$$\mathrm{RFC} = \mathrm{FC}/\mathrm{N} \quad (1)$$

where, FC = frequency of citation

N = total no of respondents.

Use Reports (UR) refers to the number of informants mentioning each use category for the species. It determines the total uses for each use category for the species by all informants [12].

$$\mathrm{UR_s} = \sum_{\mu=\mu_1}^{\mu_{NC}} \sum_{i=i_1}^{i_N} \mathrm{UR}_{\mu i} \quad (2)$$

where NC =total number of use categories

N = total number of informants.

The cultural importance index (CI) was calculated by adding the percentage of informants who cited each of the usage categories for a specific species. CI represents the diversity of plant uses and the degree of recognition of information sources for each use category [12].

$$\mathrm{CI} = \sum_{\mu=\mu_1}^{\mu_{NC}} \sum_{i=i_1}^{i_N} \mathrm{UR}_{\mu i}/\mathrm{N} \quad (3)$$

where *NC* = total number of use categories

N = total number of informants

UR = use reports

i = respondents μ = use category.

3. Results

3.1. Inventory of Neglected and Underutilised Crops

The present study aimed at exploring and cataloging the neglected and underutilized crop species, focusing on their nutritional, ethnobotanical, and agricultural attributes in the districts (Mirzapur and Sonebhadra) of eastern Uttar Pradesh. A comprehensive survey during the period of March 2018–February 2020 resulted in the documentation of 116 NUCs, belonging to 55 botanical families and spanning across 103 genera, as listed in Table 2. It was observed that all recorded NUCs had medicinal applications among the locals. However, only 55 NUCs were found to be edible and used as food, and a subset of 41 NUCs out of 116 species had specific use in the agro-ecosystem. In terms of botanical families, Fabaceae had the highest number of species (10), followed by Solanaceae (7), Convolvulaceae and Apocynaceae (each with 6 species), and Amaranthaceae (5 species). Other families, such as Moraceae and Lamiaceae, had 4 species each, while Araceae, Astereaceae, Brassicaceae, Cucurbitaceae, Euphorbiaceae, Malvaceae, Poaceae, and Rutaceae had 3 species each. Several families, including Asclepiadaceae, Cacteaceae, Combretaceae, Dioscoreaceae Meliaceae Menispermaceae, Papaveraceae, Phyllanthaceae, Plantaginaceae, and Sapotaceae, had two species each, and the remaining botanical families were represented by one species. Table 2 provides a detailed list of the recorded NUCs, including their taxonomic families, vernacular names, plant life forms, and recorded abundance in the study region. Among the documented species, herbs were the most common plant life form (50 species), followed by trees (31 species), shrubs (17 species), and climbers (16 species), and the least common

was twiners with 2 species. During the survey, it was found that most of the NUCs were fairly abundant in the region. For example, among trees, *Azadirachta indica* and *Ziziphus jujube* were the most abundant species, while *Terminalia catappa* and *Sesbania grandiflora* were the least abundant. In the case of shrubs, *Calotropis gigantea* and *Carissa caranda* were the most abundant, whereas *Plumbago zeylanica* and *Vitex negundo* were the least abundant. Among herbs, *Senna tora*, *Brassica rapa* var. *rapa*, and *Trigonella foenum-graecum* were the most abundant, while *Rauwolfia serpentina* was the least abundant. For climbers, *Lablab purpureus* and *Momordica diocia* were the most abundant, whereas *Piper betle* and *Psophocarpus tetragonolobus* were the least abundant. Lastly, among twiners, *Hemidesmus indicus* and *Operculina turpethum* were recorded, with similar levels of abundance.

Table 2. Detailed list of the documented neglected and underutilised crop from Mirzapur and Sonebhadra region of Eastern Uttar Pradesh.

Sr. No	Scientific Name	Family	Vernacular Name	Habit	Abundance	FC	RFC	Use Category			UR	CI
								F	M	A		
1.	*Achyranthes aspera* L.	Amaranthaceae	Latjeera	Herb	+++	23	0.05	0	23	0	23	0.05
2.	*Acorus calamus* L.	Acoraceae	Bach	Herb	++	17	0.04	0	17	0	17	0.04
3.	*Ageratum conyzoides* (L.) L.	Asteraceae	Gamdona	Herb	++	31	0.07	0	31	0	31	0.07
4.	*Albizia lebbeck* (L.) Benth.	Fabaceae	Siris	Tree	++	12	0.03	0	12	0	12	0.03
5.	*Aloe barbadensis* Mill.	Asphodelaceae	Ghritkumari	Herb	+	267	0.60	0	143	0	143	0.32
6.	*Argemone mexicana* L.	Papaveraceae	Bhambhad	Herb	+++	71	0.16	0	71	0	71	0.16
7.	*Argyreia nervosa* (Burm. f.) Bojer	Convolvulaceae	Vidhara	Climber	+	176	0.40	0	176	0	176	0.40
8.	*Asparagus racemosus* Willd.	Asparagaceae	Satavar	Climber	++	113	0.25	0	113	0	113	0.25
9.	*Azadirachta indica* A.Juss.	Meliaceae	Neem	Tree	+++	321	0.72	0	301	0	301	0.68
10.	*Bacopa monnieri* (L.) Wettst.	Plantaginaceae	Brahmi	Herb	+	241	0.54	0	241	0	241	0.54
11.	*Bixa orellana* L.	Bixaceae	Sindoor	Tree	++	41	0.09	0	41	0	41	0.09
12.	*Boerhavia diffusa* L.	Nyctaginaceae	Gadahpurna	Herb	++	41	0.09	0	41	0	41	0.09
13.	*Bryophyllum pinnatum* (Lam.) Oken	Crassulaceae	Pathari Ghas	Herb	++	65	0.15	45	65	0	110	0.25
14.	*Blumea lacera* (Burm.f.) DC.	Asteraceae	Kukraundha	Herb	+++	23	0.05	0	23	0	23	0.05
15.	*Caesalpinia bonduc* (L.) Roxb.	Fabaceae	Karanj	Shrub	+	76	0.17	0	76	0	76	0.17
16.	*Calotropis gigantea* (L.) Dryand.	Asclepiadaceae	Madar	Shrub	+++	34	0.08	0	34	0	34	0.08
17.	*Careya arborea* Roxb.	Lecythidaceae	Kumbhi	Tree	++	27	0.06	0	27	0	27	0.06
18.	*Carissa carandas* L.	Apocynaceae	Karonda	Shrub	+++	298	0.67	234	78	37	349	0.78
19.	*Cassia fistula* L.	Fabaceae	Amaltas	Tree	++	54	0.12	0	54	0	54	0.12
20.	*Catharanthus roseus* (L.) G. Don	Apocynaceae	Sadabahar	Herb	++	67	0.15	0	67	0	67	0.15
21.	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	Kundru	Climber	+++	301	0.70	198	56	105	359	0.81
22.	*Cocculus hirsutus* (L.) Diels	Menispermaceae	Jal Jammni	Climber	+++	65	0.15	0	65	0	65	0.15
23.	*Cuscuta reflexa* Roxb.	Convolvulaceae	Amarbel	Climber	++	13	0.03	0	13	0	13	0.03
24.	*Cymbopogon citratus* (DC.) Stapf	Poaceae	Lemon Grass	Herb	++	278	0.62	76	211	0	287	0.64
25.	*Cynodon dactylon* (L.) Pers.	Poaceae	Safeed Doob	Herb	+++	51	0.11	0	51	0	51	0.11
26.	*Canavalia gladiata* (Jacq.) DC.	Fabaceae	Sema	Climber	+	297	0.67	211	52	112	375	0.84
27.	*Datura innoxia* Mill.	Solanaceae	Datura	Herb	++	12	0.03	0	12	0	12	0.03
28.	*Digera muricata* (L.) Mart.	Amaranthaceae	Chanchali	Herb	+++	154	0.35	98	69	0	167	0.38
29.	*Dioscorea bulbifera* L.	Dioscoreaceae	Ratalu	Climber	++	201	0.45	167	49	67	283	0.64
30.	*Diospyros* emphmelanoxylon Roxb.	Ebenaceae	Tendu	Tree	++	47	0.11	0	47	0	47	0.11

Table 2. *Cont.*

Sr. No	Scientific Name	Family	Vernacular Name	Habit	Abundance	FC	RFC	Use Category			UR	CI
								F	M	A		
31.	*Echinochloa crus-galli* (L.) P. Beauv.	Poaceae	Nay Ghass	Herb	+++	121	0.27	0	121	0	121	0.27
32.	*Euphorbia hirta* L.	Euphorbiaceae	Dudhi Ghas	Herb	+++	81	0.18	0	81	0	81	0.18
33.	*Euphorbia neriifolia* L.	Euphorbiaceae	Sehund	Tree	++	12	0.03	0	12	0	12	0.03
34.	*Evolvulus alsinoides* (L.) L.	Convolvulaceae	Sankhpuspi	Shrub	+++	21	0.05	0	21	0	21	0.05
35.	*Fumaria indica* (Haussk.) Pug.	Papaveraceae	Pit Papra	Herb	+	23	0.05	0	23	0	23	0.05
36.	*Gymnema sylvestre (Retz.)* R.Br. ex Sm.	Asclepiadaceae	Gurmar	Climber	+	34	0.08	0	34	0	34	0.08
37.	*Hemidesmus indicus* (L.) R. Br. ex Schult.	Apocynaceae	Kshirini	Twiner	+	42	0.09	0	42	0	42	0.09
38.	*Holarrhena pubescens* Wall. ex G.Don.	Apocynaceae	Indrajav	Tree	+	29	0.07	0	29	0	29	0.07
39.	*Holoptelea integrifolia* (Roxb.) Planch	Ulmaceae	Chirabilva	Tree	+++	56	0.13	0	56	0	56	0.13
40.	*Ipomoea carnea* Jacq.	Convulvulaceae	Behaya	Shrub	+++	78	0.18	0	78	0	78	0.18
41.	*Justicia adhatoda* L.	Acanthaceae	Adusa	Shrub	+	123	0.28	0	123	0	123	0.28
42.	*Lablab purpureus* (L.) Sweet	Fabaceae	Sem	Climber	+++	273	0.61	146	84	117	347	0.78
43.	*Mallotus philippensis* (Lam.) Müll.Arg.	Euphorbiaceae	Rohina	Tree	+	132	0.30	0	132	0	132	0.30
44.	*Manilkara hexandra* (Roxb.) Dubard	Sapotaceae	Khirna	Tree	++	124	0.28	0	124	0	124	0.28
45.	*Mentha spicata* L.	Lamiaceae	Pudina	Herb	+++	321	0.72	231	128	0	359	0.81
46.	*Momordica dioica* Roxb. ex Willd.	Cucurbitaceae	Kheska	Climber	+++	276	0.62	167	78	89	334	0.75
47.	*Nyctanthes arbor-tristis* L.	Oleaceae	Parijat	Shrub	++	132	0.30	0	132	0	132	0.30
48.	*Ocimum sanctum* Linn.	Lamiaceae	Tulsi	Herb	+++	256	0.77	181	169	0	350	0.79
49.	*Ocimum tenuiflorum* L.	Lamiaceae	Tulsi	Herb	++	178	0.52	112	61	0	173	0.39
50.	*Operculina turpethum* (L.) Silva Manso	Convolvulaceae	Nisoth	Twiner	+	39	0.09	0	39	0	39	0.09
51.	*Opuntia dillenii* (Ker Gawl.) Haw.	Cactaceae	Naagphani	Shrub	+	41	0.09	0	41	0	41	0.09
52.	*Piper betle* L.	Piperaceae	Paan	Climber	+	213	0.48	112	141	18	271	0.61
53.	*Plumbago zeylanica* L.	Plumbaginaceae	Chitrak	Shrub	+	47	0.11	0	47	0	47	0.11
54.	*Phyllanthus niruri* L.	Phyllanthaceae	Bhumi Amla	Herb	+++	61	0.14	0	61	0	61	0.14
55.	*Phyllanthus urinaria* L.	Phyllanthaceae	Hazardana	Herb	+++	39	0.09	0	39	0	39	0.09
56.	*Psophocarpus tetragonolobus* (L.) DC.	Leguminosae	Pankho wala sem	Climber	+	21	0.05	16	7	12	35	0.08
57.	*Rauwolfia serpentina* (L.) Benth. ex Kurz.	Apocynaceae	Sarpagandha	Herb	+	183	0.41	0	183	0	183	0.41
58.	*Scoparia dulcis* L.	Plantaginaceae	Mithi Ghass	Herb	+++	34	0.08	0	34	0	34	0.08
59.	*Sida rhombifolia* L.	Malvaceae	Bariyara	Shrub	++	65	0.15	0	65	0	65	0.15
60.	*Solanum nigrum* L.	Solanaceae	Makoi	Shrub	++	187	0.42	56	161	0	217	0.49
61.	*Sesbania grandiflora* (L.) Pers.	Fabaceae	Agati	Tree	+	142	0.32	121	91	117	329	0.74
62.	*Solanum virginianum* L.	Solanaceae	Bhatkataiya	Herb	++	134	0.30	0	134	0	134	0.30
63.	*Soymida febrifuga* (Roxb.)	Meliaceae	Rohina	Tree	+	28	0.06	0	28	0	28	0.06
64.	*Swertia chirayita* (Roxb.) H.Karst.	Gentianaceae	Chirayita	Herb	++	32	0.07	0	32	0	32	0.07
65.	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Bahera	Tree	+	35	0.08	0	35	0	35	0.08
66.	*Tinospora cordifolia* (Willd.) Miers	Menispermaceae	Giloya	Climber	+++	254	0.57	151	201	0	352	0.79
67.	*Tridax procumbens* (L.) L.	Asteraceae	Narma Ghass	Herb	+++	43	0.10	0	43	0	43	0.10
68.	*Urtica dioica* L.	Urticaceae	Lakhan Jadi	Herb	+	21	0.05	0	21	0	21	0.05
69.	Vitex negundo L.	Verbenaceae	Nirgundi	Shrub	+	45	0.10	0	45	0	45	0.10
70.	*Withania somnifera* (L.) Dunal	Solanaceae	Ashwagandha	Shrub	+	35	0.08	0	35	0	35	0.08

Table 2. *Cont.*

Sr. No	Scientific Name	Family	Vernacular Name	Habit	Abundance	FC	RFC	Use Category			UR	CI
								F	M	A		
71.	*Amaranthus viridis* L.	Amaranthaceae	Jangali chaulai	Herb	+++	365	0.82	278	107	0	385	0.87
72.	*Basella alba* L.	Basellaceae	Poi/poya	Climber	++	176	0.62	113	49	66	228	0.51
73.	*Brassica juncea* var. *rugosa*	Brassicaceae	Ghorrai	Herb	++	187	0.64	113	78	98	289	0.65
74.	*Celosia argentea* L.	Amaranthaceae	Siriyari	Herb	+	32	0.07	0	32	0	32	0.07
75.	*Chenopodium album* L.	Amaranthaceae	Bathua	Herb	+++	328	0.74	303	56	0	359	0.81
76.	*Cleome gynandra* L.	Cleomaceae	Hulhul	Herb	++	12	0.03	0	12	0	12	0.03
77.	*Colocasia antiquorum* (L.) Schott	Araceae	Banda	Herb	+++	167	0.60	107	38	69	214	0.48
78.	*Colocasia esculenta* (L.) Schott	Araceae	Arvi	Herb	+++	201	0.55	153	47	117	317	0.71
79.	*Corchorus olitorius* L.	Malvaceae	Chench	Herb	+	32	0.07	11	32	0	43	0.10
80.	*Ipomoea aquatica* Forssk.	Convolvulaceae	Karemua	Herb	++	321	0.72	287	78	0	365	0.82
81.	*Leucas aspera* (Willd.) L.	Lamiaceae	Gumbi	Herb	++	12	0.03	0	12	0	12	0.03
82.	*Murraya koenigii* (L.)	Rutaceae	Kari patta	Tree	+++	256	0.72	161	69	121	351	0.79
83.	*Moringa oleifera* Lam.	Moringaceae	Sahjan	Tree	++	293	0.66	187	104	91	382	0.86
84.	*Portulaca oleracea* L.	Portulacaceae	Lethariya	Herb	++	176	0.40	141	63	0	204	0.46
85.	*Senna tora* (L.) Roxb.	Caesalpiniaceae	Chakvat	Herb	+++	27	0.06	12	15	0	27	0.06
86.	*Talinum fruticosum* (L.) Juss.	Talinaceae	Basale	Herb	+	49	0.11	41	34	31	106	0.24
87.	*Trigonella foenum-graecum* L.	Fabaceae	Methi	Herb	+++	234	0.53	203	78	113	394	0.89
88.	*Oxalis articulate* Savigny	Oxalidaceae	Amrul	Herb	++	61	0.14	45	27	0	72	0.16
89.	*Aegle marmelos* (L.)	Rutaceae	Bail	Tree	++	203	0.64	167	89	85	341	0.77
90.	*Annona squamosa* L.	Annonaceae	Sharifa	Tree	++	231	0.52	167	34	87	288	0.65
91.	*Aristotelia chilensis* (Molina) Stuntz	Elaeocarpaceae	Jangali makoi	Shrub	++	118	0.27	67	73	0	140	0.31
92.	*Artocarpus heterophyllus* Lam.	Moraceae	Kathal	Tree	+++	287	0.64	201	31	121	353	0.79
93.	*Artocarpus lacucha* Buch.-Ham.	Moraceae	Barhar	Tree	+	122	0.27	102	62	39	203	0.46
94.	*Cordia myxa* L.	Boraginaceae	Nitora	Tree	++	54	0.12	41	39	22	102	0.23
95.	*Ficus racemosa* L.	Moraceae	Gullar	Tree	+	167	0.38	116	54	32	202	0.45
96.	*Grewia asiatica* L.	Malvaceae	Falsa	Tree	+	219	0.49	189	127	47	363	0.82
97.	*Limonia acidissima* L.	Rutaceae	Kiatha	Tree	+	132	0.30	112	61	19	192	0.43
98.	*Madhuca longifolia* var. latifolia (Roxb.) A.Chev.	Sapotaceae	Mahua	Tree	+	256	0.58	145	56	46	247	0.56
99.	*Morus alba* L.	Moraceae	Shahtoot	Shrub	+	199	0.45	123	23	41	187	0.42
100.	*Melothria heterophylla* (Lour.) Cogn	Cucurbitaceae	Pehtul	Climber	++	211	0.47	187	87	22	296	0.67
101.	*Neolamarckia cadamba* (Roxb.) Bosser	Rubiaceae	Kadamb	Tree	+	254	0.57	221	79	15	315	0.71
102.	*Phyllanthus emblica* L.	Phyllanthaceae	Amla	Tree	++	356	0.80	245	53	28	326	0.73
103.	*Physalis angulata* L.	Solanaceae	Patkova	Herb	+++	311	0.70	256	67	0	323	0.73
104.	*Physalis peruviana* L.	Solanaceae	Rasbhari	Shrub	+++	287	0.64	254	67	45	366	0.82
105.	*Pithecellobium dulce* (Roxb.) Benth.	Fabaceae	Jangle jalebi	Tree	+	181	0.41	151	43	21	215	0.48
106.	*Solanum villosum* Mill.	Solanaceae	Makoi	Shrub	+++	167	0.38	121	54	0	175	0.39
107.	*Tamarindus indica* L.	Fabaceae	Imli	Tree	++	322	0.72	234	113	23	370	0.83
108.	*Terminalia catappa* L.	Combretaceae	Jangli badam	Tree	+	145	0.33	101	47	23	171	0.38
109.	*Ziziphus jujube* Mill.	Rhamnaceae	Ber	Tree	+++	211	0.47	187	56	41	284	0.64
110.	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	Araceae	Suran	Herb	+++	286	0.87	189	57	121	367	0.82
111.	*Brassica oleracea* var. gongylodes L.	Brassicaceae	Ganth gobhi	Herb	++	245	0.70	211	34	117	362	0.81
112.	*Brassica rapa* var. *rapa*	Brassicaceae	Shalgam	Herb	+++	231	0.78	176	37	137	350	0.79

Table 2. *Cont.*

Sr. No	Scientific Name	Family	Vernacular Name	Habit	Abundance	FC	RFC	Use Category			UR	CI
								F	M	A		
113.	*Dioscorea alata* L.	Dioscoreaceae	Khamalu	Herb	+	39	0.09	21	13	8	42	0.09
114.	*Ipomoea batatas* (L.) Lam.	Convolvulaceae	Shakarkand	Herb	+++	245	0.78	189	41	134	364	0.82
115.	*Nelumbo nucifera* Gaertn.	Nelumbonaceae	Kamal	Herb	++	211	0.47	187	78	56	321	0.72
116.	*Pueraria tuberosa* (Willd.) DC.	Fabaceae	Patal Kohda	Climber	+	56	0.13	34	27	3	64	0.14

Abundance: High (+++), Medium (++), Low (+). Use category: Food (F), Medicine (M), Agriculture (A).

3.2. Traditional Knowledge on Medicinal Application of Reported NUCs

The local population in the surveyed region relies on locally available neglected and underutilized crops (NUCs) for treating various ailments due to their accessibility, affordability, and effectiveness in comparison to modern medicines. The medicinal applications of all the documented NUCs can be found in Table 3. Among the plant parts used for medicinal purposes, leaves were the most commonly utilized (41.4%), followed by roots (8.6%) and stems (4.3%), as shown in Figure 2B. Flowers were the least utilized plant part for medicinal purposes (0.9%). It is worth noting that in approximately 34.5% of the cases, two or more plant parts from a single species were used in combination to treat various ailments, as depicted in Figure 2. In the study region, NUCs were employed for the treatment of various conditions such as dysentery, cough, skin infections, diabetes, obesity, and rheumatoid arthritis (see Table 3). The most prevalent forms of NUC utilization for medicinal purposes were decoctions (51.72%), powder (2.59%), paste (0.86%), fruit juice (1.72%), and vapor inhalation (0.86%), as shown in Figure 2C. Additionally, the plants were often used in combinations, such as decoction and powder (14.66%), decoction and paste (12.93%), decoction and poultice (0.86%), decoction and fruit juice (3.45%), as well as paste and powder (1.72%). During the survey, a majority of the respondents, including local traditional medical practitioners, affirmed the effectiveness of NUCs in treating a wide range of conditions. In some cases, these NUCs were used in conjunction with modern medicine. The use of these plant species as medicinal remedies is attributed to their perceived minimal or lack of side effects, as well as their cost-effectiveness. This affordability factor remains a significant reason why rural communities prefer local and herbal medicines over commercially available synthetic medicines. Figure 3 depicts some of the medicinal NUCs, whereas Supplementary Figure S1 shows the on-field demonstration and mode of application of *Ageratum Conyzoides* and *Scoparia dulcis*.

Table 3. List of reported NUCs for medicinal uses with plant parts, mode of administration and treatment of ailments.

Sr. No	Species	Part Used	Form	Uses
1.	*Achyranthes aspera* L.	R	D	Dysentery, dropsy, stomach ache, skin eruption
2.	*Acorus calamus* L.	L	D	Cough, menstrual cramps
3.	*Ageratum conyzoides* (L.) L.	S & L	D & Pt	Common cold, wound, headache
4.	*Albizia lebbeck* (L.) Benth.	S & B	D & Pd	Eye Problem (Redness of Eye), allergy
5.	*Aloe barbadensis* Mill.	L	D	Constipation, diabetes, wound healing
6.	*Argemone mexicana* L.	R & S	D & Pd	Malaria, kidney pains, bladder trouble
7.	*Argyreia nervosa* (Burm. f.) Bojer	R & L	D & Pd	Headache, anemia, skin infection, blood purification.
8.	*Asparagus racemosus* Willd.	R	D	Night blindness, acidity, ulcer, infertility, diabetes
9.	*Azadirachta indica* A. Juss.	L & R	D & Pd	Skin infection, chicken pox, acne, fever, eczema.
10.	*Bacopa monnieri* (L.) Wettst.	L	D	Woundv healing, dysentery, kidney stones
11.	Bixa orellana L.	L & B	D & Pd	Itching, fever, ulcer
12.	*Boerhavia diffusa* L.	L	D & Pt	Laxative, headache, anemia, night blindness
13.	*Bryophyllum pinnatum* (Lam.) Oken	L	D & Pd	Ulcer, skin infection, gall bladder stone

Table 3. *Cont.*

Sr. No	Species	Part Used	Form	Uses
14.	*Blumea lacera* (Burm.f.) DC.	L	Pt	Skin infection, eczema
15.	*Caesalpinia bonduc* (L.) Roxb.	L	D, Pt &Pd	Diabetes, leprosy, acne
16.	*Calotropis gigantea* (L.) Dryand.	B	Vi	Cough, asthma
17.	*Careya arborea* Roxb.	L	D	Cough, fever
18.	*Carissa carandas* L.	L, R, Fl, Fr	D & Pt	Diarrhea, fever, earache, itching
19.	*Cassia fistula* L.	S, B & R	D	Rheumatic, haemorrhage, wounds, ulcers, boils
20.	*Catharanthus roseus* (L.) G. Don	L	D	Diarrhea
21.	*Coccinia grandis* (L.) Voigt	L	D	Diabetes, high blood pressure, obesity, gonorrhea
22.	*Cocculus hirsutus* (L.) Diels	L	D & Pt	Eczema, skin diseases
23.	*Cuscuta reflexa* Roxb.	S	D	Body pains, itchy skin, jaundice, cough
24.	*Cymbopogon citratus* (DC.) Stapf	L	D	Spasms, convulsions, vomiting, cough, rheumatism, fever, common cold
25.	*Cynodon dactylon* (L.) Pers.	L	D	Piles, skin, eye problems, bleeding disorder
26.	*Canavalia gladiata* (Jacq.) DC.	S	D	Asthma, obesity, stomach-ache, dysentery, headache, epilepsy, swellings
27.	*Datura innoxia* Mill.	S	D	Hemorrhoids, kidney stones, edema, stomach upset
28.	*Digera muricata* (L.) Mart.	L & S	D	Digestive system disorders, constipation
29.	*Dioscorea bulbifera* L.	T	D	Stomach ache, cough
30.	*Diospyros melanoxylon* Roxb.	Fr, L, B & Fl	Pd	Rheumatoid arthritis, abdominal pain, malaria, Skin diseases
31.	*Echinochloa crus-galli* (L.) P. Beauv.	L	D & Pt	Wounds, carbuncles, spleen trouble
32.	*Euphorbia hirta* L.	R	D	Asthma, bronchitis, chest congestion
33.	*Euphorbia neriifolia* L.	L	D	Ear pain, warts, skin diseases, scabies
34.	*Evolvulus alsinoides* (L.) L.	L, S & B	D	Bowel disorders, dysentery, fevers, nervous debility, syphilis, scrofula
35.	*Fumaria indica* (Haussk.) Pug.	L	D	Skin infection, eye irritation, constipation
36.	*Gymnema sylvestre* (Retz.) R.Br. ex Sm.	L	D	Diabetes, obesity, cough
37.	*Hemidesmus indicus* (L.) R. Br. ex Schult.	R	Pt & Pd	Inflammation & rheumatic joints
38.	*Holarrhena pubescens* Wall. ex G.Don.	B	D	Diarrhea, jaundice, bloody dysentery, cold cough
39.	*Holoptelea integrifolia* (Roxb.) Planch	L	D & Pt	Leucoderma, rheumatism, edema, diabetes, leprosy skin diseases, intestinal disorders, piles
40.	*Ipomoea carnea* Jacq.	L	D	Leucoderma, convulsions
41.	*Justicia adhatoda* L.	L	D	Chest congestion, common colds, cough, asthma
42.	*Lablab purpureus* (L.) Sweet	S	D	Inflammation of ears and throat
43.	*Mallotus philippensis* (Lam.) Müll. Arg.	L	D	Contraceptive for women
44.	*Manilkara hexandra* (Roxb.) Dubard	S & B	D	Cough, indigestion, skin problems
45.	*Mentha spicata* L.	L	D	Stomach disorders, eye irritation
46.	*Momordica dioica* Roxb. ex Willd.	Fr & L	D	Diabetes, cough, cold
47.	*Nyctanthes arbor-tristis* L.	L	D	Liver disease (hepatitis), abdominal pain, diarrhea, dysentery, cancer
48.	*Ocimum sanctum* Linn.	L	D	Stomach spasms, worm infections, snake and insect bites
49.	*Ocimum tenuiflorum* L.	L	D	Flu, diabetes, common cold, headache, fever, earache
50.	*Operculina turpethum* (L.) Silva Manso	R	D & Pd	Constipation, fever, chronic gout, ulcers, bronchitis, tumors, hemorrhoids, jaundice, obesity
51.	*Opuntia dillenii* (Ker Gawl.) Haw.	L & Fr	D	Cervical, ovarian and bladder cancer
52.	*Piper betle* L.	L	D & P	Stomach upset and constipation
53.	*Plumbago zeylanica* L.	R	D	Gastrointestinal diseases and wounds
54.	*Phyllanthus niruri* L.	L	D	Kidney stone, jaundice, skin infections
55.	*Phyllanthus urinaria* L.	L	D	Jaundice, bronchitis, asthma, leprosy, anemia
56.	*Psophocarpus tetragonolobus* (L.) DC.	L	D	Smallpox
57.	*Rauwolfia serpentina* (L.) Benth. ex Kurz.	R	D	Hypertension, high blood pressure, cataract
58.	*Scoparia dulcis* L.	L	D & Pt	Skin Infection, anemia, diarrhea, toothache
59.	*Sida rhombifolia* L.	R	D & Pd	Rheumatism, wound, headache, constipation, fever
60.	*Solanum nigrum* L.	Fr & L	D & Pt	Asthma, whooping cough, burns, stomach upset
61.	*Sesbania grandiflora* (L.) Pers.	Fl, B & L	D & Pd	Dysentery, fever, sore throat

Table 3. *Cont.*

Sr. No	Species	Part Used	Form	Uses
62.	*Solanum virginianum* L.	S, L & S	D & Fj	Cold, bladder stone, asthma, headache, sore throat
63.	*Soymida febrifuga* (Roxb.)	S & B	D	Dysentery, fever, diarrhoea, rheumatism
64.	*Swertia chirayita* (Roxb.) H. Karst.	Ap & R	D & Pd	Joint Pain, fever, cough, asthma, diarrhea, ulcers
65.	*Terminalia bellirica* (Gaertn.) Roxb.	Fr	Fj	Chest pain, diarrhea, diabetes, immunity
66.	*Tinospora cordifolia* (Willd.) Miers	S	D, Pt &Pd	Fever, jaundice, dysentery, diarrhea, skin infection
67.	*Tridax procumbens* (L.) L.	L	D	Wound healing, heart burn, diarrhea, dysentery
68.	*Urtica dioica* L.	L	D	Arthritis, anemia, asthma
69.	*Vitex negundo* L.	L	D & Pt	Diarrhoea, asthma, dyspepsia, skin problem
70.	*Withania somnifera* (L.) Dunal	R	D & Pd	Asthma, bronchitis, edema fever, swelling
71.	*Amaranthus viridis* L.	L	D & Pt	Skin infection, wound, asthma, fever, dysentery
72.	*Basella alba* L.	L	D & Pt	Skin acne, improve bowel movement, ulcer, diarrhea
73.	*Brassica juncea* var. *rugosa*	L	D	Foot Ache, arthritis, rheumatism
74.	*Celosia argentea* L.	L	D & Pt	Wounds, skin eruptions, stomach ache
75.	*Chenopodium album* L.	L	D & Pt	Constipation, stomach ache, mouth ulcers
76.	*Cleome gynandra* L.	L & R	D	Enema, bronchitis, fever
77.	*Colocasia antiquorum* (L.) Schott	L & S	D	Fever, wound treatment, menstrual problem
78.	*Colocasia esculenta* (L.) Schott	L & S	D	Conjunctivitis
79.	*Corchorus olitorius* L.	L	D & Pt	Fever, stomach pain, acne, ulcer, headache, Diarrhea
80.	*Ipomoea aquatica* Forssk.	L	D	Jaundice, anemia, constipation, fever, cough
81.	*Leucas aspera* (Willd.) L.	L	D	Eye sight, fever, cough, snake bite
82.	*Murraya koenigii* (L.)	L	D & Pt	Dysentery, morning sickness, vomiting
83.	*Moringa oleifera* Lam.	L & P	D	Obesity, kidney stone, night blindness, constipation
84.	*Portulaca oleracea* L.	L	D	Burns, toothache, high fever, swelling
85.	*Senna tora* (L.) Roxb.	L & R	D	Cough, constipation, eczema, indigestion
86.	*Talinum fruticosum* (L.) Juss.	R	D	Diarrhoea, sore mouth, dysentery
87.	*Trigonella foenum- graecum* L.	L & S	D	Cough, diabetes, cholesterol, mouth ulcer
88.	*Oxalis articulate* Savigny	Fl	D	Urinary disorders, diarrhea, skin disorder
89.	*Aegle marmelos* (L.)	Fr, L & B	D & Fj	Constipation, dyspepsia, conjunctivitis
90.	*Annona squamosa* L.	L	D	Anemia, common cold
91.	*Aristotelia chilensis* (Molina) Stuntz	Fr	Fj	Dysentery, diarrhea, kidney pain, eye diseases
92.	*Artocarpus heterophyllus* Lam.	R & L	D & Pd	Fever, wound healing, skin diseases, asthma
93.	*Artocarpus lacucha* Buch.-Ham.	B & S	D & Pd	Liver, diabetes, wounds, stomach pain, headache
94.	*Cordia myxa* L.	Fr, B & L	D, Pd & Fj	Cough, rheumatisms, ulcers, skin infection
95.	*Ficus racemosa* L.	L & R	D, Pt &Pd	Diarrhea, dysmenorrhea, ulcer, tonsillitis, gonorrhea, skin diseases, cough, weakness
96.	*Grewia asiatica* L.	L & Fr	D, Pd & Fj	Fever, wound healing, diabetes, asthma
97.	*Limonia acidissima* L.	Fr	D, Pd & Fj	Dysentery, diarrhoea, ulcers, stomach upsets
98.	*Madhuca longifolia* var. latifolia (Roxb.) A.Chev.	Fl & B	D & Pd	Wound healing, piles, common cold, stomachache
99.	*Morus alba* L.	Fr	D & Fj	Urinary incontinence, constipation, common cold
100.	*Melothria heterophylla* (Lour.) Cogn	Fr	Pd	Seminal debility, gonorrhea, dysuria
101.	*Neolamarckia cadamba* (Roxb.) Bosser	L	D & Pd	Wound healing, urinary tract infection, diabetes
102.	*Phyllanthus emblica* L.	Fr	Fj & Pd	Constipation, stomach ulcer, diabetes, obesity
103.	*Physalis angulata* L.	L & Fr	D, Pt & Fj	Asthma, diabetes, hepatitis, boost immunity
104.	*Physalis peruviana* L.	L & Fr	D & Fj	Asthma, blood cholesterol level, diabetes
105.	*Pithecellobium dulce* (Roxb.) Benth.	Fr, B & R	D, Pt &Pd	Haemoptysis, diarrhoea, dysentery, constipation
106.	*Solanum villosum* Mill.	Fr & l	Pt & Pd	Asthma, whooping cough, burns, stomach upset
107.	*Tamarindus indica* L.	B & L	D & Pd	Cough, diabetes, diarrhea, dysentery
108.	*Terminalia catappa* L.	Fr & L	D	skin eruption, eye irritation, digestive problem
109.	*Ziziphus jujube* Mill.	R	D	Dyspepsia, fever, old wounds, ulcer
110.	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	T	Pd	Piles, dysentery, vomiting
111.	*Brassica oleracea* var. gongylodes L.	L	D	Indigestion, diabetes, cholesterol, weight loss
112.	*Brassica rapa* var. rapa.	L	D & Pd	Constipation, stomachache, weight loss

Table 3. *Cont.*

Sr. No	Species	Part Used	Form	Uses
113.	*Dioscorea alata* L.	T	Pt & Pd	Piles, skin infection, sunburn, blood pressure
114.	*Ipomoea batatas* (L.) Lam.	L	D	Improve bowel movement, asthma
115.	*Nelumbo nucifera* Gaertn.	L & Fl	D	Diarrhea, dysentery, poor digestion
116.	*Pueraria tuberosa* (Willd.) DC.	T	D	Dysuria, dysentery, chest pain, boosts body immunity

Abbreviations: Root (R), Fruit (Fr), Leaves (L), Tuber (T), Bark (B), Flower (Fl), Aerial Part (Ap), Stem (S), Decoction (D), Paste (Pt), Powder (Pd), Fruit Juice (Fj), Vapor Inhalation (Vi), Poultice (P).

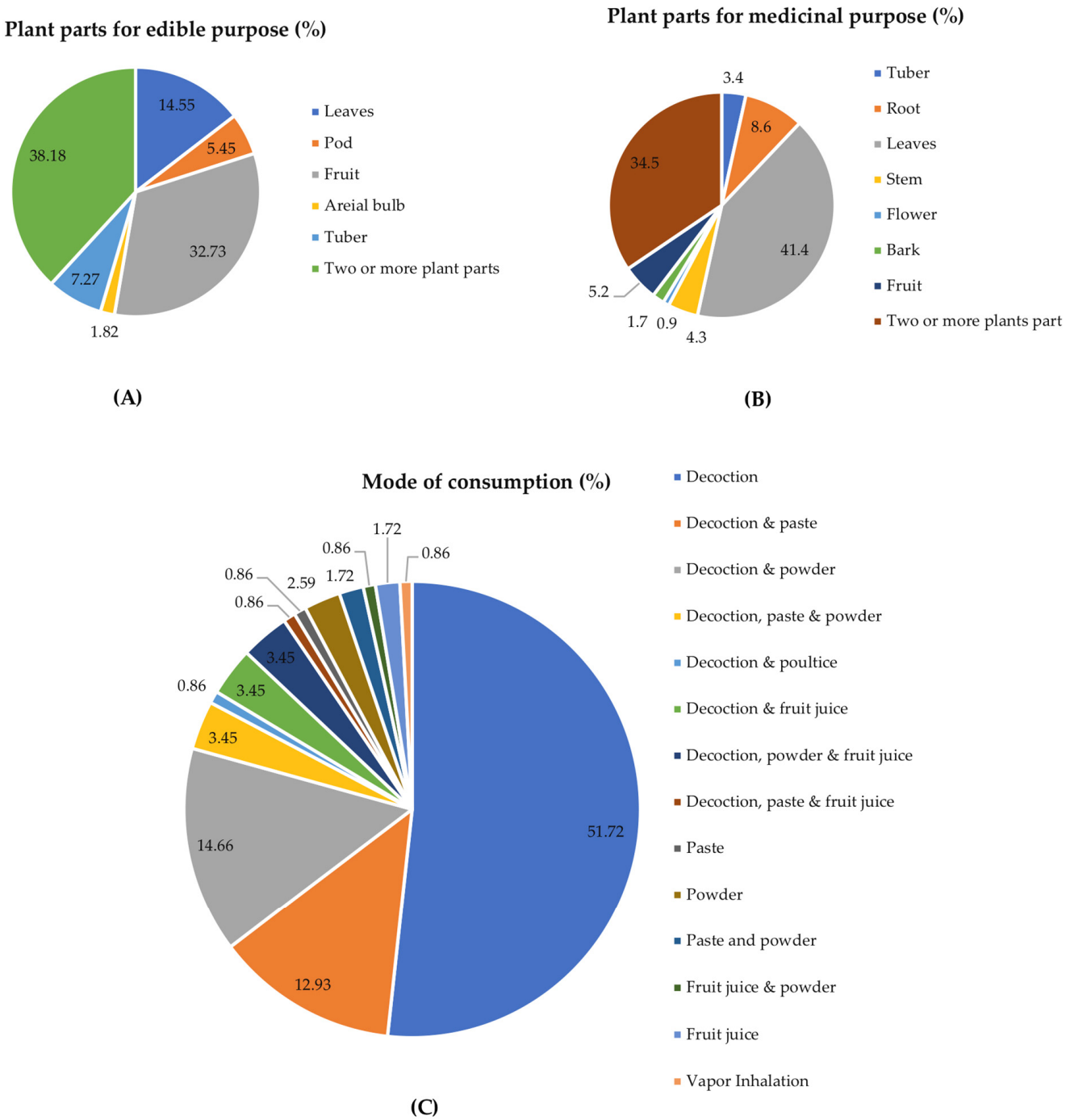

Figure 2. (**A**) Showing the percentage plants parts used for edible purpose, (**B**) percentage plants parts for medicinal purpose, (**C**) mode of consumption.

Figure 3. Some promising NUCs exhibiting medicinal application from the survey region (**A**) *Moringa oleifera*, (**B**) *Cymbopogon citratus*, (**C**) *Nyctanthes arbor-tristis*, (**D**) *Terminalia bellirica* (both tree and fruit), (**E**) *Argyreia nervosa*, (**F**,**G**) *Datura innoxia*, (**H**) *Caesalpinia bonduc*, (**I**) *Euphorbia neriifolia*, (**J**) *Plumbago zeylanica*, (**K**) *Justicia adhatoda*, (**L**) *Phyllanthus niruri*, (**M**) *Evolvulus alsinoides*, (**N**) *Ipomoea carnea*, (**O**) *Cocculus hirsutus*, (**P**) *Blumea lacera*, (**Q**) *Argemone mexicana*, (**R**) *Sida rhombifolia*, (**S**) *Solanum nigrum*, (**T**,**U**) *Euphorbia hirta*, (**V**) *Scoparia dulcis*, (**W**) *Sesbania grandiflora*, (**X**) *Calotropis gigantea*, (**Y**) *Tridax procumbens*, (**Z**) *Ageratum conyzoides*, (**AA**) *Acorus calamus*, (**AB**) *Mentha spicata*, (**AC**) *Catharanthus roseus*, (**AD**) *Cuscuta reflexa*, (**AE**) *Aloe barbadensis*, (**AF**) *Vitex negundo*, (**AG**) *Portulaca oleracea*, (**AH**) *Solanum virginianum*, (**AI**) *Holoptelea integrifolia*.

3.3. Ethnobotanical Indices for Reported NUCs

3.3.1. Frequency of Citation and Relative Frequency Citation

In the current research, the frequency of citation (FC) and relative frequency of citation (RFC) values displayed variations among the documented species. The frequency of citations ranged from 12 to 365, while the relative frequency of citation values was between 0.03 and 0.82. Notably, the species *Amaranthus viridis* had the highest FC and RFC values of 365 and 0.82, respectively, indicating that it was cited most frequently by the respondents due to its diverse and abundant utility within the local community. Another commonly utilized species was *Phyllanthus emblica*, which had an FC of 356 and an RFC of 0.80. *Chenopodium album* followed closely behind with an FC of 328 and an RFC of 0.74. Additionally, *Tamarindus Indica* had an FC of 322 and an RFC of 0.72, while *Azadirachta*

indica, *Mentha spicata*, and *Ipomea aquatica* reported FC values of 321 and an RFC of 0.72, respectively. On the other end of the spectrum, species such as *Albizia lebbeck*, *Leucas aspera*, *Cleome gynandra*, *Euphorbia neriifolia*, and *Datura innoxia* exhibited the lowest FC and RFC values, both at 12 and 0.03, respectively.

3.3.2. Use Category

Our study categorized the use of NUCs into three main categories: food (F), medicine (M), and agriculture (A), based on their documented attributes and purposes. Specifically focusing on the food category, *Chenopodium album* had the highest value with a score of 303. On the other hand, *Dioscorea alata* (F = 21), *Psophocarpus tetragonolobus* (F = 16), *Senna tora* (F = 12), and *Corchorus olitorius* (F = 11) had the lowest scores in terms of food use. In the medicinal use category, *Azadirachta indica* had the highest score with M = 301, indicating its significant usage in traditional medicine. In contrast, *Psophocarpus tetragonolobus* had the lowest score (M = 7), followed by *Euphorbia neriifolia* (M = 12), *Dioscorea alata*, and *Cuscuta reflexa* (M = 13). Lastly, in the agricultural use category, *Brassica rapa* var. *rapa* had the highest score of 137 and was closely followed by *Ipomoea batatas* with a score of 134. Conversely, *Piper betle* (A = 18), *Neolamarckia cadamba* (A = 15), and *Psophocarpus tetragonolobus* (A = 12) were among the species with the lowest scores in the agricultural use category.

3.3.3. Use Reports (UR) and Cultural Importance Index (CI)

Trigonella foenum-graecum has the highest number of use reports (UR = 394), indicating its widespread importance across all categories, followed by *Amaranthus viridis* (UR = 385) and *Moringa oleifera* (UR = 382). On the other hand, *Cuscuta reflexa* (UR = 13), *Albizia lebbeck*, *Datura innoxia*, *Euphorbia neriifolia*, and *Cleome gynandra* (UR = 12) have the lowest number of use reports. The value of CI ranges from 0.03 to 0.89. Among the reported species, the highest CI was reported by *Trigonella foenum-graecum* (CI = 0.89), followed by *Amaranthus viridis* (CI = 0.87), *Moringa oleifera* (CI = 0.86), *Canavalia gladiata* (CI = 0.84), *Tamarindus indica* (CI = 0.83), *Ipomoea batatas* (CI = 0.82), *Amorphophallus paeoniifolius* (CI = 0.82), *Physalis peruviana* (CI = 0.82), and *Grewia asiatica* (CI = 0.82). The lowest CI was observed in the cases of *Leucas aspera* (CI = 0.03), *Cleome gynandra* (CI = 0.03), *Euphorbia neriifolia* (CI = 0.03), *Datura innoxia* (CI = 0.03), *Cuscuta reflexa* (CI = 0.03), and *Albizia lebbeck* (CI = 0.03).

3.4. Food and Nutritional Aspects of NUCs in the Surveyed Region

The indigenous and tribal populations rely on locally available NUCs to fulfill their dietary and nutritional needs. These NUCs are consumed alongside market crops. This research has documented approximately 55 edible NUCs that are consumed by the local inhabitants of eastern Uttar Pradesh in various forms and preparations, as indicated in Table 4. Additionally, Figure 4 depicts photographs of some of these edible NUCs. Among the 55 edible species, fruits are the most commonly consumed, followed by leaves, tubers, and pods, as shown in Figure 2A. The least consumed parts are aerial bulbs. For most plants, two or more parts are used as food. During the survey, we recorded the methods of consumption for these edible NUCs, which included raw consumption, vegetable preparation, soups, curries, stir-frying, and chutneys, among others. The most prevalent form of consumption was as a vegetable, followed by raw consumption, stir-frying, and salads. Nutritional information, including mineral and vitamin content, was obtained from previously published scholarly articles, as presented in Table 5. Among the documented species, mineral contents such as sodium (Na), potassium (K), magnesium (Mg), manganese (Mn), zinc (Zn), copper (Cu), calcium (Ca), phosphorus (P), and iron (Fe), as well as vitamins such as ascorbic acid (Vitamin C), thiamine (Vitamin B1), and β-carotene, were analyzed for 48 species. The highest calcium content was found in *Leucas aspera* (1147.3 mg/100 g), while *Colocasia esculenta* had the highest sodium content (270 mg/100 g), *Grewia asiatica* had the highest phosphorus content (294 mg/100 g), *Talinum fruticosum* had the highest zinc content (84.6 mg/100 g), and *Phyllanthus emblica* had the

highest vitamin C content (1561.1 mg/100 g). *Carissa carandas* had the highest vitamin B1 content (2.4 mg/100 g). Furthermore, *Dioscorea bulbifera* had the highest β-carotene content (93.6 mg/100 g) and potassium content (1600.3 mg/100 g). Additionally, *Trigonella foenum-graecum* had the highest copper content (15.4 mg/100 g) and iron content (327.6 mg/100 g), *while Senna tora* had the highest manganese content (42.5 mg/100 g) and magnesium content (468 mg/100 g). Strikingly, the nutritional data for a few edible species, i.e., *Pueraria tuberosa*, *Melothria heterophylla*, *Mentha spicata*, and *Madhuca longifolia* var. *lontifolia* has not been reported yet.

Table 4. List of reported neglected and underutilised crops with their consumable parts and mode of consumption from the surveyed region.

Sr. No	Species	Part Used	Means of Consumption
1.	*Aegle marmelos* (L.)	Fr	Raw, sherbet and other beverage
2.	*Amaranthus viridis* L.	L, S	Salad, stir fry, vegetables, soup, curry
3.	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	T	Boiled, roast, vegetable
4.	*Annona squamosa* L.	Fr	Raw, sherbet
5.	*Aristotelia chilensis* (Molina) Stuntz	Fr	Raw, sherbet and other beverages
6.	*Artocarpus heterophyllus* Lam.	Fr	Vegetable and fruit
7.	*Artocarpus lacucha* Buch.-Ham.	Fr	Fruit, curries, chutney and pickle
8.	*Basella alba* L.	L, S	Salad, stir fry, vegetables, soup, curry
9.	*Brassica juncea* var. *rugosa*	L, S	Salad, stir fry, vegetables, soup, curry
10.	*Brassica oleracea* var. *gongylodes* L.	L, T	Raw, vegetable
11.	*Brassica rapa* var. *rapa*	L, T	Raw, vegetable
12.	*Canavalia gladiata* (Jacq.) DC.	P	Vegetable
13.	*Carissa carandas* L.	Fr	Raw, pickle and beverages
14.	*Celosia argentea* L.	L, S	Stir fry, vegetables, soup, curry
15.	*Chenopodium album* L.	L, S	Stir fry, vegetables, soup, curry
16.	*Cleome gynandra* L.	L, P	Stir fry, vegetables, soup, curry
17.	*Coccinia grandis* (L.) Voigt	Fr	Vegetables
18.	*Colocasia antiquorum* (L.) Schott	L, T	Boil, roast, vegetable
19.	*Colocasia esculenta* (L.) Schott	L, T	Boil, roast, vegetable
20.	*Corchorus olitorius* L.	L	Vegetables
21.	*Cordia myxa* L.	Fr, Fl	Vegetable and Pickle
22.	*Digera muricata* (L.) Mart.	L	Vegetables, soup, stir fry
23.	*Dioscorea alata* L	T	Boil, vegetable
24.	*Dioscorea bulbifera* L.	AB	Vegetable
25.	*Ficus racemosa* L.	Fr	Vegetables, pickle
26.	*Grewia asiatica* L.	Fr	Raw, sherbets and other beverages
27.	*Ipomoea aquatica* Forssk	L, S	Stir fry, vegetables, soup, curry
28.	*Ipomoea batatas* (L.) Lam.	T	Raw, boil, roasted, vegetable
29.	*Lablab purpureus* (L.) Sweet	P	Vegetable, pickle
30.	*Leucas aspera* (Willd.) L.	L	Vegetables
31.	*Limonia acidissima* L.	Fr	Raw, chutneys, sherbets
32.	*Madhuca longifolia* var. *latifolia* (Roxb.) A.Chev.	Fr, Fl	Raw
33.	*Melothria heterophylla* (Lour.) Cogn	Fr	Raw and vegetables
34.	*Mentha spicata L.*	L	Raw, cooked
35.	*Moringa oleifera* Lam.	L, Fl, P	Vegetables, soup, curry
36.	*Morus alba* L.	Fr	Raw, beverages
37.	*Murraya koenigii* (L.)	L, Fl	Vegetables, soup, curry
38.	*Nelumbo nucifera* Gaertn.	T, Sd	Raw, vegetable, sweet dishes
39.	*Neolamarckia cadamba* (Roxb.) Bosser	Fr	Raw and beverages.

Table 4. *Cont.*

Sr. No	Species	Part Used	Means of Consumption
40.	*Oxalis articulate* Savigny	L	Vegetable and chutney
41.	*Phyllanthus emblica* L.	L, Fr	Raw, pickled, Chutney, beverage
42.	*Physalis angulata* L.	Fr	Raw
43.	*Physalis peruviana* L.	Fr	Raw
44.	*Pithecellobium dulce* (Roxb.) Benth.	P	Raw
45.	*Portulaca oleracea* L.	L	Vegetables, soup, curry
46.	*Psophocarpus tetragonolobus* (L.) DC.	L, Fl, S, P, T	Vegetable
47.	*Pueraria tuberosa* (Wild.) DC.	T	Raw, sweet dishes
48.	*Senna tora* (L.) Roxb	L	Vegetables
49.	*Sesbania grandiflora* (L.) Pers	P, Fl	Raw, vegetable, soup and curry
50.	*Solanum nigrum* L.	Fr	Raw
51.	*Talinum fruticosum* (L.) Juss.	L, Fl, S	Vegetables, soup, curry
52.	*Tamarindus indica* L.	L, Fr	Raw, chutney, flavoring agent
53.	*Terminalia catappa* L.	Fr	Raw
54.	*Trigonella foenum–graecum* L.	L	Raw, vegetables, soup, curry
55.	*Ziziphus jujube* Mill.	Fr	Raw

Abbreviations: Leaves (L), Stem (S), Flower (Fl), Fruit (Fr), Pod (P), Seed (Sd), Tuber (T), Aerial bulb (AB).

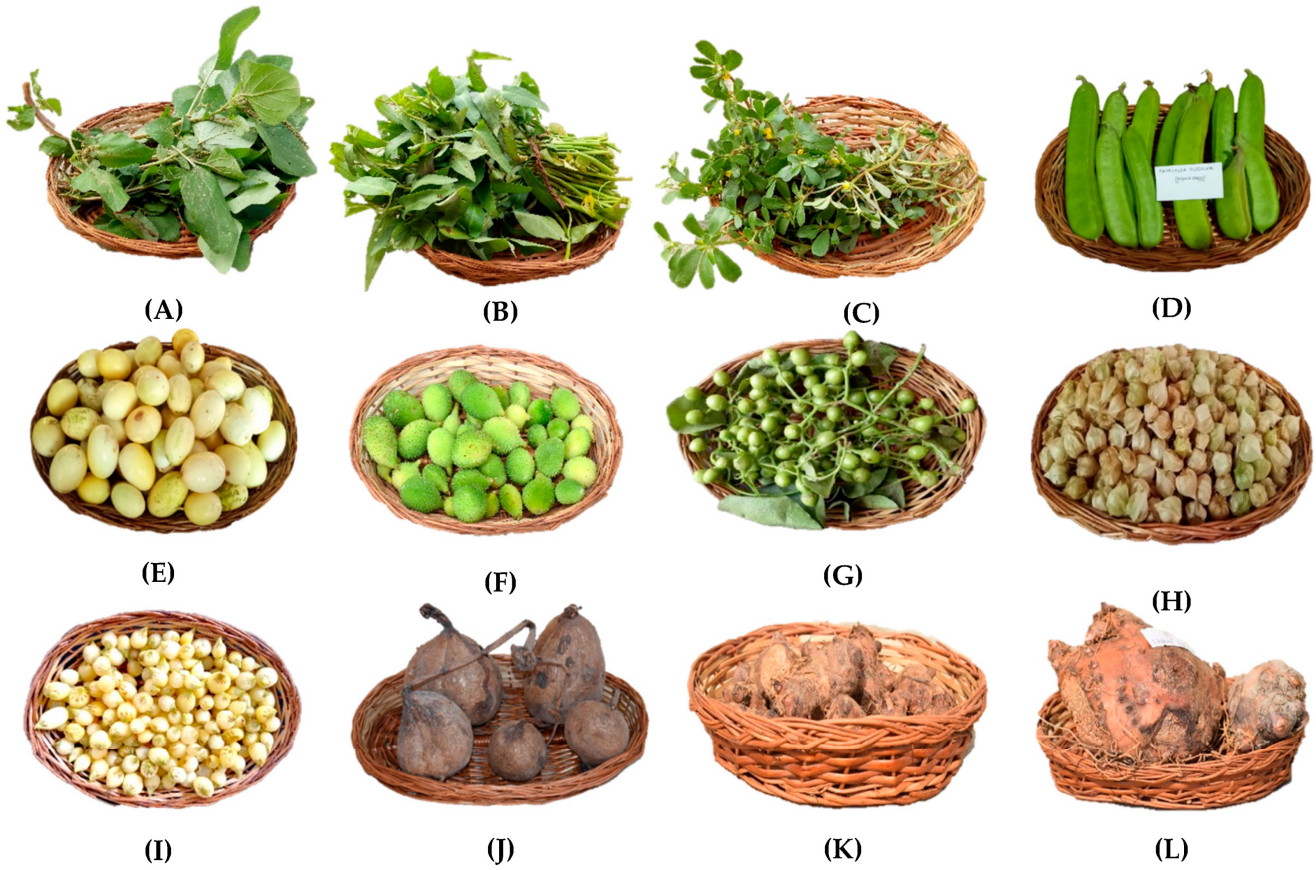

Figure 4. Edible parts of some promising NUCs from the study region. (**A**) *Amaranthus viridis* (**B**) *Ipomoea aquatica* (**C**) *Portulaca oleracea* (**D**) *Canavalia gladiata* (**E**) *Melothria heterophylla* (**F**) *Momordica dioica* (**G**) *Cordia myxa* (**H**) *Physalis angulata* (**I**) *Madhuca longifolia* (**J**) *Pueraria tuberosa* (**K**) *Colocasia esculenta* (**L**) *Amorphophallus paeoniifolius*.

Table 5. Nutritional attributes of some of the edible neglected and underutilised crops documented from the study region.

Sr. No	Species	Minerals (mg/100 g)									Vitamins (mg/100 g)			References
		Ca	K	Mg	Na	P	Fe	Zn	Cu	Mn	Vit. C	Vit. B1	β-Carotene	
1.	*Aegle marmelos* (L.)	86.6	603.0	4.0	20.0	50.0	3.3	15.8	1.2	1.5	8.0	0.1	55	[17–20]
2.	*Amaranthus viridis* L.	215.0	670.0	55.0	56.0	50.0	5.4	1.2	0.2	0.7	43.3	-	4.8	[21–23]
3.	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	161.0	327.8	33.0	3.0	166.9	3.4	0.9	1.2	0.4	6.0	0.6	0.2	[24–26]
4.	*Annona squamosa* L.	450.0	45.0	400.0	10.0	26.8	1.7	0.3	-	-	47.1	-	-	[27,28]
5.	*Aristotelia chilensis* (Molina) Stuntz	155.8	368.3	30.9	0.4	57.6	1.3	0.3	0.1	0.3	-	-	-	[29]
6.	*Artocarpus heterophyllus* Lam.	24.0	448.0	29.0	2.0	21.0	0.2	0.1	0.1	0.1	13.7	0.1	-	[21]
7.	*Artocarpus lacucha* Buch.-Ham.	-	-	-	-	-	51.6	5.6	0.8	62.3	96.3	0.9		[30,31]
8.	*Basella alba* L.	109.0	510.0	65.0	50.6	52.0	40.2	39.3	1.2	5.8	102.0	-	12.3	[21,32–34]
9.	*Brassica juncea* var. *rugosa*	118.0	162.0	13.0	9.0	42.0	0.87	0.22	-	-	25.3	0.041	7.4	[21]
10.	*Brassica oleracea* var. *gongylodes* L.	24.0	350.0	19.0	20.0	46.0	0.4	-	0.1	0.1	62.0	-	-	[21]
11.	*Brassica rapa* var. *rapa*	30.0	191.0	11.0	67.0	27.0	0.3	0.2	-	0.1	21.0	-	-	[21]
12.	*Canavalia gladiata* (Jacq.) DC.	119	889	126	6.0	305	4.4	2.42	0.70	-	-	0.50	-	[35]
13.	*Carissa carandas* L.	21.0	5.2	59.0	3.6	38.0	39.1	2.4	-	0.1	10.5	2.4	-	[36–39]
14.	*Celosia argentea* L.	188.0	476.0	233.0	240.6	35.0	13.1	0.5	0.1	0.2	59.0	-	4.4	[40,41]
15.	*Chenopodium album* L.	309.0	855.2	112.1	43.0	72.0	4.79	0.7	-	0.5	80.0	0.1	2.7	[21,42,43]
16.	*Cleome gynandra* L.	323.5	410.0	86.0	33.6	12.0	6.0	0.7	0.4	-	305.5	-	12.8	[44]
17.	*Coccinia grandis* (L.) Voigt	3.79	3.3	-	0.95	1.15	-	-	-	-	25.55	-	70.05	[45]
18.	*Colocasia antiquorum* (L.) Schott (Tuber)	39.1	591.0	33.0	9.2	76.0	0.5	0.1	0.1	0.3	4.5	-	1.8	[21,22,46]
19.	*Colocasia antiquorum* (L.) Schott (Leaves)	110.0	378.0	206.0	-	-	-	-	0.1	7.8	66.1	-	-	[47]
20.	*Colocasia esculenta* (L.) Schott (Leaves)	225.0	648.0	45.0	270.8	36.0	59.0	1.3	6.7	0.3	6.0	0.2	-	[21,41,48,49]
21.	*Colocasia esculenta* (L.) Schott (Tuber)	132.0	591.0	45.9	185.1	84.0	81.8	5.4	10.0	0.3	14.3	-	-	[21]
22.	*Corchorus olitorius* L.	28.0	8.9	15.2	13.4	11.5	27.2	67.5	2.4	36.5	101.7	0.1	2.6	[32,50,51]
23.	*Cordia myxa* L.	4.6	78.3	-	16.2	275.0	5.1	3.5	-	2	-	-	-	[52]
24.	*Digera muricata* (L.) Mart.	506.0	604.0	232.0	-	63.0	17.7	0.5	0.1	0.2	49.0	0.1	3.3	[53]
25.	*Dioscorea alata* L	38.0	397.0	15.0	12.0	28.0	1.1	0.3	0.2	6.3	6.0	0.1	-	[24,54,55]
26.	*Dioscorea bulbifera* L.	238.1	1600.3	441.1	66.7	134.1	4.9	1.3	2.7	11.6	13.3	0.8	93.6	[56,57]
27.	*Ficus racemosa* L.	72.0	508.0	35.0	23.0	47.0	1.3	0.3	0.1	-	1.0	0.5	-	[58]
28.	*Grewia asiatica* L.	820.3	814.5	6.5	264.0	294.1	27.1	2.0	1.5	5.1	4.3	-	-	[59,60]
29.	*Ipomoea aquatica* Forssk	416.7	-	301.6	135.0	109.2	210.3	2.4	0.3	2.1	-	-	-	[61]
30.	*Ipomoea batatas* (L.) Lam.	133.0	1018.0	86.0	192.0	184.0	3.6	4.3	0.7	0.5	2.4	-	1.8	[21,61]
31.	*Lablab purpureus* (L.) Sweet	50	252	40	2	49	0.74	0.37	0.047	0.205	12.9	0.077	-	[21]
32.	*Leucas aspera* (Willd.) L.	1147.3	374.0	189.0	6.3	59.0	70.1	4.4	1.4	1.9	29.6	0.1	1.3	[47,62–64]
33.	*Limonia acidissima* L.	71.1	494.3	85.2	9.5	113.7	2.3	2.3	0.6	0.3	18.0	-	-	[65,66]
34.	*Moringa oleifera* Lam.	24.0	448.0	29.0	3.0	21.0	0.23	0.1	0.2	0.3	58.1	0.2	4.0	[21,22]
35.	*Morus alba* L.	139.0	1141.0	109.0	60.0	235.0	4.3	3.1	0.4	4.0	22.4	-	-	[67]
36.	*Murraya koenigii* (L.)	19.7	-	49.0	16.5	-	0.16	-	12.0	3.5	0.04	0.8	6.0	[22,68–70]
37.	*Nelumbo nucifera* Gaertn.	44.0	367.0	56.0	1.0	168.0	0.9	0.2	-	0.6	-	0.1	-	[21]
38.	*Neolamarckia cadamba* (Roxb.) Bosser	123.7	36.7	71.0	10.7	-	28.2	11.0	4.1	13.7	35.7	-	14.3	[71,72]
39.	*Oxalis articulate* Savigny	24.5	5.1	23.4	-	12.9	0.7	0.1	-	0.3	58.3	-	-	[73]
40.	*Phyllanthus emblica* L.	27.6	282.0	11.8	4.2	28.2	3.3	1.8	0.2	1.1	1561.1	-	-	[74–77]
41.	*Physalis angulata* L.	-	3.0	1.9	68.9	3.0	0.2	-	3.0	1.9	26.2	0.1	-	[78–80]
42.	*Physalis peruviana* L.	8.0	320.0	34.7	1.0	55.0	1.2	0.4	0.2	0.2	43.0	0.1		[70,81,82]
43.	*Pithecellobium dulce* (Roxb.) Benth.	-	2.6	1.5	1.0	-	0.1	2.6	1.6	-	-	-	-	[83]

Table 5. *Cont.*

Sr. No	Species	Minerals (mg/100 g)									Vitamins (mg/100 g)			References
		Ca	K	Mg	Na	P	Fe	Zn	Cu	Mn	Vit. C	Vit. B1	β-Carotene	
44.	*Portulaca oleracea* L.	65.0	494.0	68.0x	45.0	44.0	20.1	0.1	0.1	0.3	21.0	-	3.9	[22,41,84]
45.	*Psophocarpus tetragonolobus* (L.) DC.	191.5	293	58	3.2	47.5	1.25	0.2	0.6	2.2	-	-	-	[85]
46.	*Senna tora* (L.) Roxb	144.0	820.0	468.0	181.0	84.0	20.1	22.8	33.3	42.5	44.6	-	5.6	[22,41,86,87]
47.	*Solanum nigrum* L.	11.8	37.1	201.3	2.1	62.5	12.9	-	-	-	23.3	-	-	[88]
48.	*Talinum fruticosum* (L.) Juss.	8.4	26.6	6.3	36.3	15.3	39.2	84.6	2.2	12.5	-	-	-	[32]
49.	*Tamarindus indica* L.	74.0	628.0	92.0	28.0	113.0	2.8	0.1	-	0.1	3.5	0.4	-	[21,22,58]
50.	*Terminalia catappa* L.	230.0	688.0	335.0	6.0	-	4.6	4.9	2.0	1.2	4.0	-	-	[89]
51.	*Trigonella foenum- graecum* L.	395.0	31.0	67.0	76.0	51.0	327.6	9.8	15.4	9.9	52.0	-	1.2	[22,90,91]
52.	*Sesbania grandiflora* (L.) Pers (Flower)	62	180	0.80	28	-	-	0.30	-	22	-	-	-	[74]
53.	*Ziziphus jujube* Mill.	21.0	250.0	10.0	3.0	23.0	0.4	-	-	-	69.0	-	-	[21]

Data Unavailibility is represented by "dash (-)".

3.5. Agricultural Relevance of NUCs in Surveyed Region

Neglected and underutilized crops are preferred over other crops due to their adaptability to local climate changes and their ability to thrive in a wide range of environmental conditions. Consequently, there has been an increasing interest in utilizing NUCs as promising agricultural crops. However, current knowledge about the agricultural potential of neglected and underutilized crops remains relatively localized and limited. Therefore, one of the objectives of this study was to document the agricultural potential of NUCs through interactions with local farmers and field observations of the methods employed to exploit the agricultural traits of these crops. The documented NUCs were commonly found in spaces such as kitchen gardens, backyard gardens, and as border crops, but large-scale cultivation was observed to be limited to a few species. The neglected and underutilized crops documented in this region are grown in different agronomic and agro-ecological settings, i.e., some are grown as major crops such as *Grewia asiatica*, *Moringa oleifera*, and *Colocasia esculenta*, while tree species are preferably grown as agroforestry components such as *Madhuca longifolia* var. *latifolia*, *Morus alba*, *Pithecellobium dulce*, *Tamarindus indica*, and *Terminalia catappa*. Additionally, other NUC species were grown for varied potential, such as *Melothria heterophylla*, as a mixed crop with fodder crops. Similarly, in the case of cabbage leaf mustard, it is grown in a mixed and inter-cropping system, while the majority of the crops are grown in different roles, such as intercrop, border crop, mixed crop, and major crop. A detailed account of the agricultural potential of the crop species is depicted in Table 6. Field photographs for reporting the exploitation of NUCs in small-scale settings mainly for family use for their dietary diversification, while large-scale field cultivation for increased income is shown in Supplementary Figure S2 and Figure 5, respectively. Furthermore, among the reported agricultural potential of the species, the most peculiar finding was the cultivation of *Nelumbo nucifera* by a few farmers and the utilization of different plant parts by the local people from the survey region.

Table 6. Agricultural potential of most promising NUCs for large scale cultivation.

Sr. No	Species	Cultivation Potential
1.	*Carissa carandas* L.	Major crop, border crop, agroforestry
2.	*Coccinia grandis* (L.) Voigt	Major crop, border crop
3.	*Canavalia gladiata* (Jacq.) DC.	Major crop, intercropping, mixed cropping, border crop
4.	*Dioscorea bulbifera* L.	Mixed crop, border crop

Table 6. *Cont.*

Sr. No	Species	Cultivation Potential
5.	*Lablab purpureus* (L.) Sweet	Major crop, Inter crop, mixed crop, border crop
6.	*Mentha spicata* L.	Mixed crop, inter crop
7.	*Momordica dioica* Roxb. ex Willd.	Major crop, mixed crop
8.	*Piper betle* L.	Major crop, mixed crop, inter crop
9.	*Psophocarpus tetragonolobus* (L.) DC.	Major crop, mixed crop, inter crop, border crop
10.	*Sesbania grandiflora* (L.) Pers	Major crop, agroforestry
11.	*Basella alba* L.	Major crop, mixed crop, inter crop, border crop
12.	*Brassica juncea* var. *rugosa*	Mixed crop, Inter crop
13.	*Colocasia antiquorum* (L.) Schott	Major crop, mixed crop, inter crop, border crop
14.	*Colocasia esculenta* (L.) Schott	Major crop, mixed crop, inter crop, border crop
15.	*Murraya koenigii* (L.)	Major crop, agroforestry
16.	*Moringa oleifera* Lam.	Major crop, agroforestry
17.	*Talinum fruticosum* (L.) Juss.	Major crop, mixed crop, inter crop
18.	*Trigonella foenum–graecum* L.	Major crop, mixed crop, intercrop, border crop
19.	*Aegle marmelos* (L.)	Major crop, agroforestry
20.	*Annona squamosa* L.	Major crop, agroforestry
21.	*Artocarpus heterophyllus* Lam.	Major crop, agroforestry
22.	*Artocarpus lacucha* Buch.-Ham.	Major crop, agroforestry
23.	*Grewia asiatica* L.	Major crop
24.	*Limonia acidissima* L.	Major crop, agroforestry
25.	*Madhuca longifolia* var. *latifolia* (Roxb.) A.Chev.	Agroforestry
26.	*Morus alba* L.	Agroforestry
27.	*Melothria heterophylla* (Lour.) Cogn	Mixed crop with fodder
28.	*Neolamarckia cadamba* (Roxb.) Bosser	Agroforestry
29.	*Phyllanthus emblica* L.	Agroforestry
30.	*Physalis peruviana* L.	Major crop, intercrop, mixed crop, border crop
31.	*Pithecellobium dulce* (Roxb.) Benth.	Agroforestry
32.	*Tamarindus indica* L.	Agroforestry
33.	*Terminalia catappa* L.	Agroforestry
34.	*Ziziphus jujube* Mill.	Border crop, agroforestry
35.	*Amorphophallus paeoniifolius* (Dennst.) Nicolson	Major crop, intercrop
36.	*Brassica oleracea* var. gongylodes L.	Major crop, border crop, intercrop, mixed crop
37.	*Brassica rapa* var. *rapa*	Major crop, border crop, intercrop, mixed crop
38.	*Dioscorea alata* L.	Major crop, intercropping and mixing with other tubers
39.	*Ipomoea batatas* (L.) Lam.	Major crop, intercropping and mixing with other tubers
40.	*Nelumbo nucifera* Gaertn.	Major aquatic crop
41.	*Pueraria tuberosa* (Willd.) DC.	Mixed crop, intercrop

Figure 5. Examples of agricultural field level cultivation of some of the neglected and underutilised crop species by local farmers in the study region for additional income generation. (**A**,**B**) The cultivation *Dolichos lablab* (leguminous crop) with *Allium sativum* and cultivation of *Dolichos lablab* with seasonal leafy vegetables as crop diversification, (**C**) Large scale cultivation of *Colocasia esculenta*, (**D**) Large scale cultivation of *Colocasia esculenta* with *Allium cepa* can boost income with diversification in comparison with cultivation of just *Colocasia esculenta*, (**E**,**F**) Large scale cultivation of *Grewia asiatica* and *Ipomoea batatas* respectively.

4. Discussion

The present study, conducted in eastern Uttar Pradesh, aimed to document the significance of neglected and underutilized crops (NUCs) among the local population. The results of the study demonstrate that NUCs play a pivotal role in the lives of the local people through various functions, encompassing medicine, food, and agricultural diversification to utilize degraded and marginal land. Throughout the study, it became evident that knowledge pertaining to the utilization of NUCs was closely associated with age, with older individuals being more aware of the level and methods of utilizing locally available NUCs, which aligns with previous reports documenting the local use of such crops [92]. The transfer of information about the utilization of these crops occurs within families, serving as an important means of preserving traditional and local knowledge. The involvement of the local and indigenous populations played a crucial role in the entire study, as they facilitated the transfer of traditional and cultural knowledge that culminated over generations. The sustainable utilization of NUCs can contribute to diversifying food systems, reducing dependence on limited options, and boosting the income of rural households. Additionally,

NUCs not only promote food diversification but also play a crucial role in fortifying diets and enhancing dietary quality, particularly in low- and medium-income countries [93,94].

The growing awareness and increasing popularity of neglected and underutilized crops (NUCs) as "future smart crops" have spurred scientists and researchers worldwide to document these lesser-utilized crops in their respective regions. Similar studies, such as those by Mondo et al. [10], revealed the utilization of 22 NUCs in Kabare and Walungu territories in Bukavu, D.R. Congo. Neupane and Poudel [95] documented 92 NUC species in the Lamjung district of Nepal, while Nasution et al. [96] reported the use of 106 NUCs in the Mandailing community and 44 NUCs among the Batak Toba people in Peadungdung village, North Sumatra, including both wild and cultivated varieties. Sukenti et al. [97] discovered 22 NUCs employed in Sasak cuisine on Lombok Island, Indonesia, and Sujarwo et al. [98] documented 86 NUCs used in Bali. In the Indian context, there have been very limited studies documenting the role and diverse applications of NUCs in improving the livelihoods of locals. One such study was conducted by the M.S. Swaminathan Research Foundation (MSSRF) in collaboration with Bioversity International, focusing solely on minor millets to enhance income generation and alleviate poverty [99]. Additionally, a study was conducted in the foothills of the Eastern Himalayan region to document underutilized fruits that can be exploited for food security and their desirable genes [100].

4.1. Important and Widely Used NUCs from Eastern Uttar Pradesh

The significance and utilization of NUCs are closely linked to their distribution and abundance in an area. Our study reveals that the availability of plants directly influences where they are collected, while local culture plays a vital role in determining their utilization patterns. Moreover, the number of uses associated with a particular plant, as reported by an informant, reflects their intrinsic knowledge and understanding of its properties. In the current study, the most widely utilized plant was *Trigonella foenum-graceum* (FC = 234, UV = 394, CI = 0.89), which exhibited the highest usage report and CI due to its abundant presence and versatile applications among the local population. This plant is valued for its nutraceutical properties and finds application in various forms, including raw consumption as a vegetable, in soups, and in curries. Additionally, its agricultural relevance in the study region further contributes to its extensive utilization. *Amaranthus viridis* (FC = 365, UV = 385, CI = 0.87) emerged as another popular leafy vegetable, consumed by 278 respondents in diverse culinary preparations such as salads, stir-fries, vegetable dishes, soups, and curries. Furthermore, it is recognized for its medicinal properties, with 107 respondents reporting its use in treating ailments such as skin infections, wounds, asthma, fever, and dysentery. Supporting this, numerous reports have also documented the diverse use of *A. viridis* as both food and medicine, including its efficacy in managing conditions such as diarrhea, fever, and snakebites [101,102]. *Moringa oleifera* (FC = 293, UV = 382, CI = 0.86) stands as a versatile tree, with all its plant parts being edible and possessing valuable nutraceutical attributes. It is consumed as a vegetable, in soups, and in curries, while also being utilized as traditional medicine to address various ailments. Its agricultural significance and the multitude of benefits it offers have led to its extensive adoption by the local community. *Canavalia gladiata* (FC = 297, UV = 375, CI = 0.84), a leguminous NUC, is highly valued among the residents of Eastern Uttar Pradesh as a vegetable, a medicinal plant for conditions like obesity, stomach-aches, and dysentery, and serves as a major crop in the region. *Tamarindus indica* (FC = 322, UV = 370, CI = 0.83) is a notable plant due to its significance and diverse utilization. It finds use as a food source and a medicinal ingredient and holds agricultural relevance in various contexts. *Chenopodium album*, with a CI of 0.81, was reported by the highest number of respondents (303) in the food category, indicating the locals' preference and reliance on this NUC species. Among the respondents, women were particularly active in harvesting it for various culinary uses, such as stir-frying, as vegetables, in soups, and in curries. Similar studies have highlighted that *Chenopodium album* is a widely distributed plant species used as a diuretic, for rheumatism, and as food [103,104]. Similar studies have

reported that *Chenopodium album* is a widely distributed plant species used as a diuretic, for rheumatism, and as food [103,104]. *Azadirachta indica*, reported by the highest number of respondents (301) in the medicine category, is another plant utilized for treating several diseases, including skin infections, chickenpox, acne, fever, and eczema. It has also been reported by researchers in different parts of the world, such as Pakistan [102,105], South America [106], and Bangladesh [107], for its efficacy in managing various ailments, such as skin care, hair problems, birth control, abortion, and diabetes. Traditionally, *Sesbania grandiflora* (FC = 142, RFC = 0.32, CI = 0.74) has been used to treat diarrhea, snakebites, malaria, smallpox, fever, ulcers, and gastrointestinal disorders. The leaves of *Sesbania grandiflora* are known for their anti-cancer, anti-diabetic, anti-bacterial, anti-helminthic, anti-hyperlipidemic, and anti-diarrheal properties [108,109].

Both *Ipomoea batatas* and *Amorphophallus paeoniifolius*, tuberous plants, hold cultural significance (CI = 0.82) and serve as major cash crops in the region. They are consumed roasted, boiled, as pickles, and in vegetable preparations. Their high CI value is attributed to their agricultural and biocultural importance. Large-scale cultivation of Ipomoea batatas was reported by 134 respondents, while *Amorphophallus paeoniifolius* was cultivated by 121 respondents. These species have a strong bio-cultural association with Indian festivals. For instance, during Diwali (the festival of lights), it is believed that consuming *Amorphophallus paeoniifolius* brings happiness and prosperity to the household. On the other hand, Ipomoea batatas is closely associated with Navratri (a Hindu festival spanning nine nights, celebrated annually in autumn) and Chhath (an ancient Hindu Vedic festival). Similarly, NUCs continue to be prominently utilized in cultural and religious festivals across different parts of the world [110,111]. Noteworthy examples include the Traditional Food Festival in Sri Lanka and the Alaçatı Wild Herb Festival in Turkey [112]. These celebrations serve as platforms to foster an appreciation for the region's biodiversity, encompassing NUCs, and attract tourists, food enthusiasts, TV food channels, and chefs. The events feature captivating cooking demonstrations, delectable food tastings, and enlightening lectures that emphasize the significance of these foods in sustaining healthy and environmentally friendly diets [112,113]. Japan boasts a distinctive cultural program known as washoku, which revolves around social skills, practices, knowledge, and traditions related to food production, processing, preparation, and consumption. It embodies a profound spirit of reverence for nature, closely intertwined with the sustainable utilization of natural resources. The Japanese engage in diverse preparations to welcome the deities of the upcoming year, with a particular emphasis on consuming NUCs and edible wild plants [114].

4.2. Phytochemistry and Biological Activities of Reported NUCs

Local and indigenous people rely on traditional medicine as their first line of action for the treatment of most of their ailments, owing to the limited access and costliness of modern medicine and healthcare. Hence, ethnomedicinal knowledge is useful for the maintenance of community-based approaches under this medical system. Some of the diseases treated by NUCs in the study area are dropsy, stomach ache, skin eruption, eye problems, allergies, constipation, bladder trouble, ulcers, acne, asthma, leprosy, etc. Furthermore, some of the NUCs, such as *Momordica dioica*, *Coccinia grandis*, *Trigonella foenum-graecum*, *Grewia asiatica*, *Tamarindus indica*, and *Brassica oleracea* var. *gongylodes* L., possess very good anti-diabetic activity and are thus recommended to patients with diabetes [115–120].

Plants with medicinal uses have many phytoconstituents, such as *Aloe barbadensis*, commonly known as Aloe vera, which has phytoconstituents like aloin, aloe-emodin, aloethinic acid, aloeresin A–C, aloesone, aloeride, arabinose, and emodine, resulting in pharmacological activities such as antioxidant, antimicrobial, anticancer, anti-inflammatory, antidiabetic, antifungal, and angiogenic. In China, people use aloe juice as a mild laxative to wash for piles, scabies, and abscesses, while in the Philippines, it is used against dysentery and kidney pain. Similar studies, i.e., Duke and Ayensu, Wee and Hsuan [121,122], have reported the use of the leaves of *Nelumbo nucifera* to treat fever, dysentery, and diarrhea,

whereas the decoction of seeds is used to treat fever, kidney problems, haemoptysis, and spermatorrhoea, while the rhizome is used to treat dyspepsia, diarrhea, dysentery, ringworm, and skin ailments. The decoction of root, stem, and leaves of *Solanum nigrum* is used to treat cancerous growth, tumors, and wounds in different parts of the world owing to its phytoconstituents such as α-,β-,γ-chaconine, α-,β-solansodamine, α-solasonine, Solanidine, α-,β-,γ-solanines, α-,β-solamargine, diosgenin, desgalactotigonin, solanigroside A–H, soladulcidine, solanadiol, solasodine, solanocapsine, tigogenin, tomatidenol, uttronins A and B, uttrosides A and B This has resulted in various pharmacological activities such as antibacterial, antiviral, antioxidant, anticancer/ antineoplastic, anti-inflammatory, antiulcerogenic, antinociceptive, antimutagenic, depressant, enzyme modulation, hypolipidaemic, hepatoprotective, parasiticidal, larvicidal, and molluscicidal [123,124].

Sesbania grandiflora has phytoconstituents like beta-carotene, grandiflorol, (+)-leucocyanidin, lutein, neoxanthin, oleanolic acid, violaxanthin, and zeaxanthin [125,126] resulting in pharmacological activities like antibacterial, anticonvulsant, anti-inflammatory, anxiolytic, depressant, diuretic, hepatoprotective, hypoglycaemic, hypotensive, and haemolytic [127]. In the Philippines, it is used for its hypotensive properties, while in India, it is used to treat liver disorders [128]. *Moringa oleifera* has been extensively utilized in herbal medicine by both Indians and Africans, and it is believed to have therapeutic properties for over 300 diseases. Each part of the plant, including leaves, seeds, root bark, flowers, and pods, possesses its own medicinal importance. The presence of flavonoids gives it antidiabetic, antioxidant, anticancer, anti-inflammatory, and antibiotic properties. Traditionally, *M. oleifera* has been used to treat various ailments such as eye and ear infections, scurvy, skin diseases, bronchitis, asthma, hyperglycemia, dyslipidemia, pneumonia, diarrhea, headaches, flu, heartburn, syphilis, and malaria. It also aids in reducing blood pressure and cholesterol levels [129]. *Portulaca oleracea*, commonly known as purslane, is rich in omega-3 fatty acids, particularly α-linolenic acid, gamma-linolenic acid, and linoleic acid, which are not commonly synthesized by terrestrial plants. It possesses anti-inflammatory, antidiabetic, antitumor, anticancer, antioxidant, anti-insomnia, analgesic, antiseptic, hepatoprotective, gastroprotective, neuroprotective, skeletal muscle relaxation, and wound healing properties. *P. oleracea* is used to treat a variety of illnesses, such as headaches, diarrhea, kidney and cardiovascular problems, diabetes, and urinary infections [130]. *Neolamarckia cadamba*, a significant tree in traditional medicine, exhibits anti-malarial, analgesic, anti-inflammatory, antipyretic, diuretic, and laxative properties. Various components of the tree are used to treat fever, uterine problems, blood and skin diseases, tumors, anemia, eye inflammation, and diarrhea [131].

The tuber of *Pueraria tuberosa* contains several bioactive phytochemicals, primarily isoflavonoids such as puerarin, genistein, daidzein, and tuberosin. It is advocated for treating cardiovascular ailments, hepatosplenomegaly, fertility issues, menopausal syndrome, sexual debility, and spermatorrhea. It is also utilized in various Ayurvedic formulations as a restorative tonic, anti-aging agent, spermatogenic, and immune booster [132]. Commercial medicinal packets exploiting the medicinal attributes of *Pueraria tuberosa* are available in the Indian market. *Basella alba*, also known as Indian spinach, possesses antiviral, antioxidant, anti-inflammatory, androgenic, antidiabetic, antimicrobial, antiulcer, CNS depressant, hepatoprotective, and wound healing properties. Its different parts are used to treat various conditions, including anemia, aphthae, burns, bleeding piles, cancer, digestive disorders, skin diseases, pimples, urticaria, irritation, whooping cough, leprosy, insomnia, gonorrhea, headaches, ulcers, diarrhea, liver disorders, bilious vomiting, and sexual asthenia [133]. *Tinospora cordifolia*, an essential component of Indian medical systems, is used to treat a variety of ailments, including fevers, diabetes, dyspepsia, jaundice, urinary tract problems, acne, chronic diarrhea, dysentery, helminthiasis, leprosy, and cardiac diseases [134]. *Rauwolfia serpentina* has sedative, hypnotic, and cardio-depressant properties. It is useful for treating vertigo, sexual aggressiveness, hypertension, sleeplessness, and schizophrenia [135]. *Phyllanthus niruri* is used in Indian Ayurveda and Unani systems to treat jaundice, ulcers, skin conditions, diabetes, chest pain, and urinary issues [136]. *Euphorbia hirta*, tradi-

tionally used to treat feminine diseases, childhood worm infestations, diarrhea, jaundice, acne, gonorrhea, digestive problems, cough, coryza, bronchitis, and asthma, possesses antiviral, antioxidant, anti-inflammatory, androgenic, antidiabetic, antimicrobial, antiulcer, CNS depressant, hepatoprotective, and wound healing properties [137]. *Dioscorea bulbifera* has been used in traditional medicine worldwide to treat ulcers, sores, wounds, spasms, dysentery, diabetes, and cancer [138]. *Digera muricata*, commonly known as false amaranth, is widely used in traditional medicine, with all its parts (leaves, roots, and shoots) having medicinal properties. Shoots are particularly important medicinally, as they possess cooling and astringent effects on the bowels in small doses and act as a laxative in large doses. It is also beneficial for biliousness, and its flowers and seeds are useful in treating urinary tract discharges [53].

4.3. Relevance of NUCs in Global Food Production and Economy

According to the Crop Wild Relative, NUCs have the potential to contribute significantly to the global economy, with an estimated annual economic benefit of around 115–120 billion USD [139]. The increasing popularity of NUCs in different parts of the world can be seen in countries such as China, where around 75 million tons of sweet potatoes, as well as rhizomes and seeds of *Nelumbo nucifera* are grown over 6.6 million and 0.067 million hectares annually, respectively. Tanzania and Nigeria also contribute significantly to sweet potato production, with 3.57 and 2.73 million tonnes produced each year, respectively [140]. In Ghana, sweet potato is the fourth most important cultivated tuber, following yam, cassava, and taro, with an estimated annual production of 0.132 million tonnes across 9622 hectares of arable land [141,142]. About 96.7% of global yams are produced along the West Africa production zone [143]. Cape gooseberry has been reported to have an annual production of 13.6 tons/ha in Ecuador and 14.5 tons/ha in Colombia, with an average value of 6423.89 USD per hectare per year [144,145]. The study highlights that NUCs were considered ancillary crops in the study area and were primarily associated with rural women. This finding reflects the gender-based roles and economic dynamics commonly observed in agricultural communities, where women are primarily engaged in subsistence crop production while men show more interest in cash crops. Furthermore, promoting the cultivation of climate-resilient and nutritious crops among women can enhance livelihoods, empower women, provide sources of income, promote gender equality, and foster sustainable rural livelihoods. These results suggest that NUCs may hold specific roles and significance within the local socio-cultural context, consistent with similar findings reported by [10,146]. Given the current global agricultural scenario, there is a pressing need to shift towards an integrated approach that combines the cultivation of climate-resilient and adaptive NUCs with modern crop varieties, and this can be an innovative strategy to manage future food production under changing climatic conditions [147]. The current study also reveals that several NUCs in the area are cultivated in home gardens, kitchen gardens, backyard gardens, and along boundary walls. However, some NUCs, such as *Lablab purpureus*, *Colocasia esculenta*, *Grewia asiatica*, and *Ipomoea batatas*, are reported to be cultivated on a larger scale. Several studies have reported the positive effects of intercropping Neglected and Underutilized Crops (NUCs) with modern crops, including enhanced overall yields and weed suppression. Specifically, intercropping Taro and Bambara in a 1:1 ratio under rainfed conditions has been shown to offer several advantages compared with conventional cultivation methods [147,148].

5. Conclusions

The present exploratory study, conducted in eastern Uttar Pradesh, aimed to comprehensively enumerate and document the untapped potential of neglected and underutilized crop species (NUCs) with nutritional, ethnomedicinal, and agricultural significance. The study identified a total of 116 NUCs, all of which possess medicinal importance. Among these, 55 species are utilized as food, while 41 NUCs hold agricultural significance in both small-scale and large-scale settings. All reported NUCs have been traditionally utilized

by the indigenous communities in the study area for treating various ailments. Our study results are significant for conservationists and policymakers, especially in the context of sustainable management and utilization of these underutilized crops, which are currently facing depletion due to unsustainable management. Furthermore, the plant species identified as having significant usage can be subjected to further studies to identify their bio-active constituents through in-vivo and in-vitro studies leading to promising novel drugs as well as nutritional profiling of the edible species, including anti-nutrient substances, for potential crop improvement. To promote the utilization of NUCs, strategic intervention by public-private-government partnerships is crucial. Incentive-based farming should be encouraged among farmers to cultivate promising NUCs with multipurpose benefits. The adoption of these climate-resilient species at both small and large scales is vital to meet the food and nutritional requirements of the growing population and also to achieve the various United Nations Sustainable Development Goals (UN-SDGs).

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agronomy13092318/s1, Figure S1: On field demonstration of the medical application by the local practitioner (A) Different stages of medical application of *Ageratum conyzoides*, step 1: identification of the plant step 2: plucking of suitable tender leaves step 3: crushing the tender leaves on the palm step 4: juice drops applied directly on the eye for cleaning the eye and improving the eye sight. (B) Local tribal practitioner using freshly plucked *Scoparia dulcis* and applying the milk directly on the eyes for treating conjunctivitis. Figure S2: Field observations of cultivation of NUCs in different small space settings for diet diversification and germplasm conservation. such as (A–C) *Basella alba* is commonly observed during the study as edible nutritious crop in kitchen garden, boundary crop and backyard garden respectively, (D) *Colocasia esculenta* grown in the backyard garden of local farmer, (E) *Colocasia antiquorum* in backyard garden, (F) *Dioscorea bulbifera* in kitchen garden, (G–I) *Dolichos lablab* grown in the home garden with the support of boundary wall, (J) *Ipomoea batatas* in field as crop diversification, (K) *Brassica juncea* in field as crop diversification, (L) *Digera muricata* in kitchen garden.

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