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Ethnobotanical survey of medicinal tree species serving in gastrointestinal ailments used by tribal communities of Mandvi, South Gujarat, India

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Abstract
Introduction: Ethnobotany explains the relationships between people and plants, particularly how they utilize plants for various purposes. Mandvi taluka of Gujarat state, India, has a good forest cover with valuable medicinal properties. The study is an ethnobotanical survey that explores the floral diversity, their medicinal properties and usage by the indigenous communities. There is great importance of forests, their floral diversity, their aboriginal communities and their indigenous knowledge. This knowledge can be utilized to treat certain disease with less or no side effects.
Methods: Floral diversity was surveyed using quadrate method from September 2018 to July 2021. The ethnomedicinal study was done using semi-structured interviews, questioners and informal conversations. The findings were analysed into abundance, density, frequency, relative abundance, relative density, relative frequency, % composition and importance value index (IVI).
Result: The study records 67 plant species that serves in the Gastrointestinal (GI) disorders among which 17 species were rare and threatened. These plants are helpful in treating 14 to 20 ailments, utilized in 24 or more ways. It has been observed that bark (38%) is the most used tree part. Decoction and infusion are the most common utilization methods. Diarrhea and dysentery as commonly treated GI ailments. The quantitative analysis also shows high heterogeneity in the study area, indicating high species diversity in forests of Mandvi.
Conclusion: The present Ethnobotanical survey concludes that the Mandvi taluka about 67 tree species having medicinal properties serving in gastrointestinal ailments and the tribal community has invaluable knowledge about their usage.

Keywords: Ethnobotany, gastrointestinal disorders, mandvi, floral diversity, medicinal plants, ethnomedicine

Introduction

"Ethnobiology", a comprehensive term, is an academic discipline that explores the ever-evolving connections between human societies, living organisms, and their surrounding environments through scientific inquiry. Within the field of ethnobiology, the study of "Ethnobotany" is a constituent discipline. The term 'Ethnobotany' was initially introduced by J.W. Harshberger in 1895, a botany professor at the University of Pennsylvania. He used this term to describe the study of plants utilized by primitive and indigenous communities. Ethnobotany focuses on the scientific study of the relationships between people and plants, particularly how different cultures and societies utilize plants for various purposes (Bennett 2002) [3]. Medicinal plants play a significant role in ethnobotanical studies.

Since the ancient times, as documented in Ayurveda, the medicinal properties of plants have always been utilized by man. This traditional knowledge is passed on across generations within aboriginal communities and local populations. The therapeutic efficacy of herbal medicines in treating a wide range of ailments, such as infectious diseases and hypertension, is well-established. Their potential to save lives, especially in developing nations, is unquestionable (Patrick 2002) [34]. India being one of the developing countries, the dependency rate of tribal communities and local people on medicinal flora is quite high. Herbal treatment serves as the primary healthcare choice for over 70% of the Indian population (Vaidya & Devasagayam 2007) [49]. Herbal medical practitioners have utilized approximately 6,000 out of 15,000 herbal plant species as medicinal drugs or treatments (Dhamija et al. 2011) [13]. India is home to 427 tribal communities (Kala 2005) [21], and more than 275 papers have been published specifically focused on these ethnic groups (Jain 2001) [20].

Herbal medicines and botanicals are widely recognized for their efficacy in addressing a wide range of disease in both humans and animals, including gastrointestinal disorders. Herbal medications are considered to be highly effective therapeutic options in these cases (Blumenthal 2002 [4]; Mukheriee & Wahile 2006 [28]; Heinrich 1992 [17]; Manandhar 2002 [26]; Madikizela et al. 2012 [25]; Street &

Prinsloo 2013) [44]. Amongst humans, the gastrointestinal (GI) tract is considered the most critical organ susceptible to a range of ailments, including constipation, diarrhea, bloating, gastroenteritis, reflux, as well as parasitic and other infectious disease (Kasper 2005) [23]. Based on studies, the occurrence of diarrhea as an infectious disease varies across regions, affecting approximately 19 to 83 out of every 100 individuals annually (Porcelli 2004) [35]. Similarly, Constipation, a prevalent gastrointestinal disorder, exhibits varying prevalence rates ranging from 2.4% to 30.7% of the population (LU et al. 2006; Papatheodoridis et al. 2010 [33]; Sorouri et al. 2010 [42]; Howell et al. 2006 [18]; Adibi et al. 2007 [1]; Cottone et al. 2014 [10]; Heidelbaugh et al. 2015 [16]; Boyce et al. 2006 [5]; Ng et al. 2015) [32]. These gastrointestinal (GI) disorders are noteworthy ailments (Ziaei et al. 2008) [51] due to their impact on individuals' health and well-being. They can cause a range of uncomfortable symptoms, disrupt daily activities, and have potential long-term consequences if left untreated. To treat and cure such disorders wild medicinal plants are best options due to their compatibility with human body and minimal or no side effects (Rafieia-Kopaei 2011 [37]; Nasri & Shirzad 2013) [31].

The current research includes the ethnobotanical survey of medicinal plants focusing on gastro-intestinal disorders used by the tribal communities of Mandvi, South Gujarat, India, and the information was analyzed statistically. The extensive wealth of ethnobotanical knowledge possessed by the indigenous people of Mandvi has not been previously documented. The present study provides an overall assessment of the tree species diversity in the study area and their significance in aiding the gastrointestinal ailments. It will aid in future perspectives for conservation of this important habitat and floral diversity, along with the medicinal knowledge from tribals of the region.

Materials and Methods

Study Area

Mandvi is a taluka (tehsil) situated on the bank of Tapi River, Surat district, Gujarat, India. It is located approximately 62 km from Surat city. It is bounded by Mangrol Taluka towards North, Bardoli Taluka towards west, and Vyara Taluka and Valod Taluka towards South. The latitude and longitude of Mandvi Taluka are 21.15°N and 73.18°E respectively, and have a geographical area of 829.02 sq. km. The area is mostly arid throughout the year with warm summers. Entire study area experienced high difference in temperature going as low as 13° C in winter and high up to 45° C in summer. Mandvi is known for its agricultural activities, including the cultivation of crops such as cotton, rice, sugarcane and vegetables. The region is famous for its carpentry, blacksmith work and handlooms work. The locality provides good forest products like honey, wood, mango, and other minor forest goods.

Methodology

The forest area of Mandvi was surveyed using quadrate method. Quadrates of 20x20 sq. meter were arranged (total 185 plots) across the study area. Extensive surveys were conducted during all the seasons from September 2018 to July 2021. During this period the forest area was scan thoroughly for recording diversity of tress. Trees on roadside, ditches, ponds, etc. were also recorded. The species were recorded by direct observation, and those species which were not identified on field were photographed and samples were collected. For sampling the trees, twigs of nearly 25 cm. length with the leaves and flowers were collected in a sampling bag. Identification and nomenclature were done with the help of 'Flora of Gujarat State' (Shah 1978) [39], and Cooke's Flora (Shah 1978) [39]. Bentham and Hooker's system of classification was used for family-wise arrangement of tree species. The ethnomedicinal study was done during the field visits and the information concerning the traditional medicinal uses were gathered from the tribals and native Bhagats (healers). Semi-structured interviews, questioners and informal conversations were the methods used for data collection about the medicinal values of trees. The information gathered was compared and checked using the previous literatures of Jain (1989) [19] and Sinha (1996) [41]. During the study, quantitative analytical parameters were analyzed and studied. These parameters were abundance, density, frequency, relative abundance, relative density, relative frequency, % composition and importance value index (IVI). Standard methods of calculations and formulas were used for analysing these parameters (Braun-Blanquet 1932 [6]; Singh & Misra 1969; Misra 1968 [27]; Cottam & Curtis 1956 [9]; Tuxen 1956 [48]; Curtis 1959) [11].

Results

Floral Diversity and species richness

The study recorded 67 plant species having medicinal properties serving in gastrointestinal ailments. The plants belonged to 55 genera of 32 families. The tribals and local people use these medicinal plants or their parts to treat 14 to 20 ailments related to digestive system and alimentary canal. They use the raw plant part or make different types of formulations using the parts. The study has recorded around 24 or more formularies / treatment modes and ways of using plant part for healing or curing purpose. Table-1 provides the botanical and common names of medicinal plants (in Gujarati language78), family, parts used, ailments it treats and the mode of treatment.

Among the 32 families, family Caesalpiniaceae was dominating with 7 species, followed by Rubiaceae (5 species) and Mimosaceae (5 species). As per the number of genera, family Rubiaceae, Caesalpiniaceae and Rutaceae dominated each with 5, 4, and 4 genera, respectively. Family-wise distribution of medicinal plant species and genera is presented in Fig-1. Three families dominated with respect to the species percentage among the total 32 families. Around 10.45 % of the plant species belonged to family Caesalpiniaceae, followed by Rubiaceae (7.46 %) and Mimosaceae (7.46 %). The percentage proportion of various species in each family is presented in Fig-2.

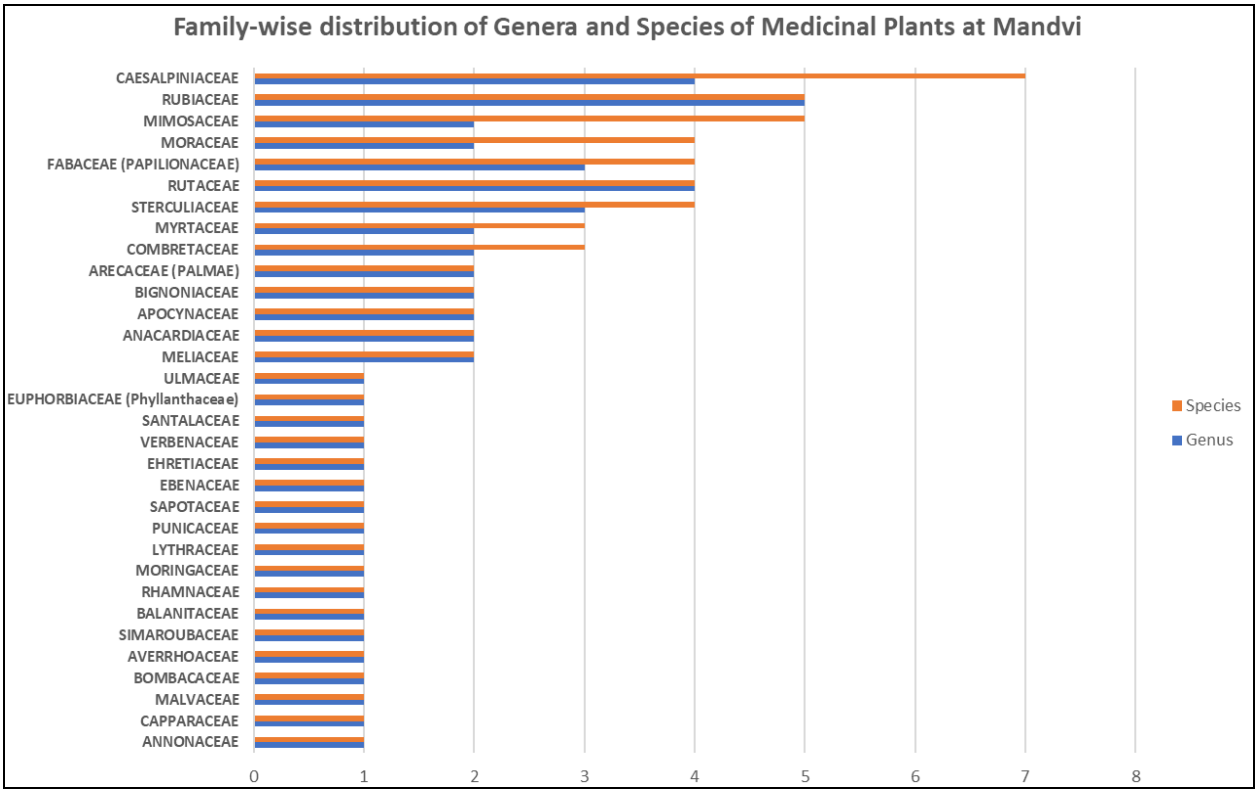

Fig 1: Family-wise distribution of Genera and Species of Medicinal Plants at Mandvi, South Gujarat, India. (in line with text)

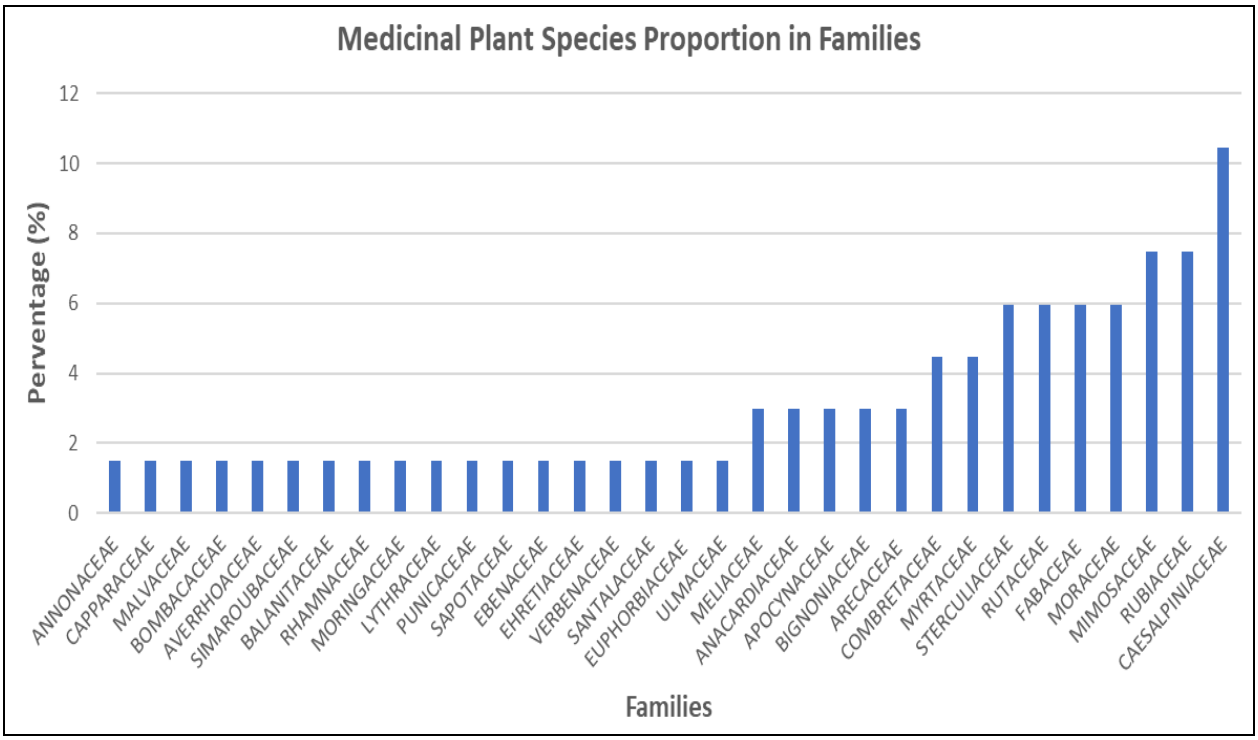

Fig 2: Percentage Proportion of Medicinal Plant Species among the Families (in line with text)

Utilization of Medicinal Tree Species for GI Disorders

During the study, various parts of the 67plant species were used such as bark, fruits, leaves, roots, seeds, stem, wood, gum, latex, pods, flowers, and oils (Fig-3). The most used part for making various formulations for treatment were Bark (38 %), Fruit (30 %), and Leaves (12 %), followed by Root, Seed, Stem, Wood, Gum, Latex, Pods, Flower and oil. These plant parts were directly used (eaten raw – ripe or unripe) or used in the form of extract, decoction, infusion, powder, juice, pulp, paste, etc.

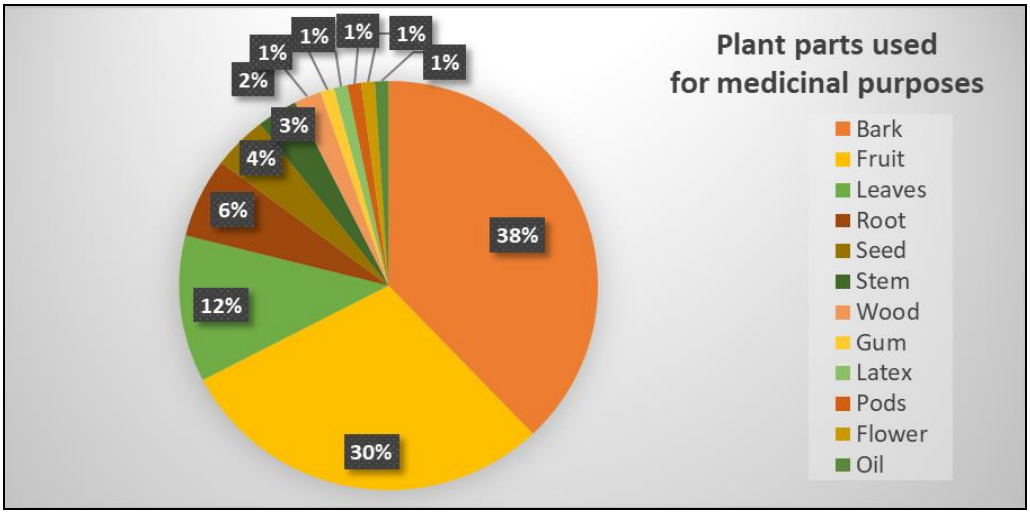

Fig 3: Plant parts used for medicinal purpose. (in line with text)

Around 14 to 20 gastrointestinal ailments were observed to get treated using the tree species and their parts. Through interviews, it was known that most treatable ailments were Diarrhea (treated using 35 tree species), Dysentery (cured using 21 species), general digestive system disorders (17 species were helpful in treatment) and vomiting (using 13 species). Table-2 lists the ailments and number of species useful for its healing. *Feronia limonia* and *Butea monosperma* are the two species with the highest medicinal efficiencies, i.e., they cure 6 types of ailments, followed by *Azadirachta indica* (curing 5 ailments) and others. The medicinal efficiency is measured by summing the ailments it cures.

Table 1: Types of Gastrointestinal Ailments. (in line with text)

Types of Gastrointestinal Ailments	Number of Plant Species curing the Ailment
Diarrhea	35
Dysentery	21
Gastrointestinal problem, digestive problem & Loss of appetite	17
Vomiting	13
Stomach ache / Gastritis	9
Intestinal parasite	7
Stomatitis	7
Dyspepsia	5
Indigestion	3
Dental pain, throat infection, cough and gargles	5
Constipation	4
Ulcer	4
Gastrointestinal tonic	2
Food Adjunct	1

Statistical Analysis of Accessible Tree Species

The vegetational quantitative analysis was done for 31 species of the total 67 species due to the accessibility issues. The analytical results are presented in Table-3. *Tectona grandis L.* was observed to have highest density and abundance, followed by *Acacia chundra (Roxb.) Willd*. Both these plant species were observed to have high relative density and relative abundance. *Tectona grandis L.* and *Butea monosperma (Lamk.) Taub*. were most frequently obtained species among the 31 accessible plant species. 26 species of the total quantitatively studied species were distributed in Raunkiaer's frequency class 'A' which indicates the heterogeneity of the community and explains the high species diversity of the study area. Percentage composition of the tree community in forest was observed to be the highest of two species, *Tectona grandis L.* and *Acacia chundra (Roxb.) Willd*. The relative contribution of a species to the community is measured by Importance Value Index (IVI). IVI also indicates the ability of a species to establish itself in a community. IVI obtained is highest for *Tectona grandis L.* and *Acacia chundra (Roxb.) Willd.*

Table 2: Phenological Study of some species. (in line with text)

Sr. No.	Botanical Name	No. of Species in 185 Plots	No. of Quadrates in which Species Occur	Density	Abundance	Frequency	Frequency Class	Relative Density	Relative Abundance	Relative Frequency	% Composition	IVI
1	*Annona squamosa L.*	2	2	0.01	1.00	1.08	A	0.09	1.64	0.31	0.09	2.04
2	*Bombax ceiba L.*	16	15	0.09	1.07	8.11	A	0.75	1.75	2.30	0.75	4.79

3	*Sterculia urens Roxb.*	6	6	0.03	1.00	3.24	A	0.28	1.64	0.92	0.28	2.84
4	*Ailanthus excelsa Roxb.*	15	8	0.08	1.88	4.32	A	0.70	3.07	1.23	0.70	5.00
5	*Azadirachta indica A. Juss.*	57	37	0.31	1.54	20.00	B	2.66	2.52	5.67	2.66	10.86
6	*Ziziphus xylopyrus (Retz.) Willd.*	18	11	0.10	1.64	5.95	A	0.84	2.68	1.69	0.84	5.21
7	*Spondias pinnata (L.) F.*	1	1	0.01	1.00	0.54	A	0.05	1.64	0.15	0.05	1.84
8	*Butea monosperma (Lamk.) Taub.*	246	85	1.33	2.89	45.95	C	11.49	4.74	13.04	11.49	29.27
9	*Dalbergia latifolia Roxb.*	17	15	0.09	1.13	8.11	A	0.79	1.85	2.30	0.79	4.95
10	*Dalbergia sissoo Roxb.*	12	3	0.06	4.00	1.62	A	0.56	6.55	0.46	0.56	7.57
11	*Pterocarpus marsupium Roxb.*	16	15	0.09	1.07	8.11	A	0.75	1.75	2.30	0.75	4.79
12	*Bauhinia purpurea L.*	2	2	0.01	1.00	1.08	A	0.09	1.64	0.31	0.09	2.04
13	*Bauhinia racemosa Lam.*	15	13	0.08	1.15	7.03	A	0.70	1.89	1.99	0.70	4.58
14	*Cassia fistula L.*	12	10	0.06	1.20	5.41	A	0.56	1.96	1.53	0.56	4.06
15	*Cassia siamea Lam.*	1	1	0.01	1.00	0.54	A	0.05	1.64	0.15	0.05	1.84
16	*Delonix regia (Boj. ex Hk.) Raf.*	1	1	0.01	1.00	0.54	A	0.05	1.64	0.15	0.05	1.84
17	*Tamarindus indica L.*	8	6	0.04	1.33	3.24	A	0.37	2.18	0.92	0.37	3.48
18	*Acacia chundra (Roxb.) Willd.*	273	68	1.48	4.01	36.76	B	12.75	6.57	10.43	12.75	29.75
19	*Acacia chundra (Roxb.) Willd.*	25	9	0.14	2.78	4.86	A	1.17	4.55	1.38	1.17	7.09
20	*Albizia procera (Roxb.) Benth.*	15	6	0.08	2.50	3.24	A	0.70	4.09	0.92	0.70	5.71
21	*Anogeissus latifolia (Roxb. ex DC.) Wall. Ex Bedd.*	10	6	0.05	1.67	3.24	A	0.47	2.73	0.92	0.47	4.12
22	*Terminalia bellirica (Gaertn.) Roxb.*	41	20	0.22	2.05	10.81	A	1.92	3.36	3.07	1.91	8.34
23	*Lagerstroemia lanceolata Wall.*	15	8	0.08	1.88	4.32	A	0.70	3.07	1.23	0.70	5.00
24	*Catunaregam spinosa (Thunb.) Tirveng.*	9	4	0.05	2.25	2.16	A	0.42	3.68	0.61	0.42	4.72
25	*Diospyros melanoxylon Roxb.*	54	36	0.29	1.50	19.46	A	2.52	2.45	5.52	2.52	10.50
26	*Holarrhena pubescens Wall. ex G.Don.*	4	3	0.02	1.33	1.62	A	0.19	2.18	0.46	0.19	2.83
27	*Wrightia tinctoria R. Br.*	215	56	1.16	3.84	30.27	B	10.04	6.28	8.59	10.04	24.92
28	*Tectona grandis L.*	952	157	5.15	6.06	84.86	E	44.48	9.92	24.08	44.47	78.48
29	*Emblica officinalis Gaertn.*	21	6	0.11	3.50	3.24	A	0.98	5.73	0.92	0.98	7.63
30	*Holoptelea integrifolia (Roxb.) Planch.*	54	36	0.29	1.50	19.46	A	2.52	2.45	5.52	2.52	10.50
31	*Ficus racemosa L.*	8	6	0.04	1.33	3.24	A	0.37	2.18	0.92	0.37	3.48

Table 3: Ethnobotanical checklist of medicinal plant species recorded in the study area. (in line with text)

Sr.No.	Botanical Name	Local Name	Family	Parts Used	Ailments	Treatment Mode
1	*Annona squamosa L.*	Sitafal	Annonaceae	Fruit	Vomiting	Eaten raw
				Seeds	Kill intestinal worms	Seed powder
2	*Capparis grandis L.*	Kerado	Capparaceae	Fruit	Gastric problems	Eaten raw
3	*Thespesia populnea (L.) Sol ex Correa.*	Paras pipalo	Malvaceae	Bark	Dysentery	Cold infusion
4	*Bombax ceiba L.*	Shemal / Shimalo	Bombacaceae	Bark	Diarrhea, Stomatitis	Aqueous extract and gum
5	*Guazuma ulmifolia Lam.*	Khoto Rudrax	Sterculiaceae	Bark	Gastrointestinal pain	Bark decoction
6	*Helicteres isora L.*	Maradashing	Sterculiaceae	Stem, Fruits	Diarrhea, dysentery, and intestinal parasites.	"Valamburi" Fruit powder is mixed with water and given as a drink
7	*Sterculia urens Roxb.*	Kadayo	Sterculiaceae	Bark	Gastric problems	Cold infusion and bark decoction
8	*Sterculia villosa Roxb.ex DC.*	Deshi Kadayo	Sterculiaceae	Root	As food adjunct	Root infusion
				Bark	Throat infection	White exudates (gum or resin)
9	*Averrhoa carambola L.*	Kamarakh	Averrhoaceae	Fruit	Intestinal parasites	Eaten raw
10	*Aegle marmelos (L.) Corr.*	Bili	Rutaceae	Bark	Vomiting	Bark decoction
				Fruit	Chronic dysentery	Fruit juice
11	*Citrus reticulata Blanco.*	Santara	Rutaceae	Fruit	Dyspepsia, gastro-intestinal distension, vomiting	Eaten raw
12	*Feronia limonia (L.) Swingle.*	Kothi	Rutaceae	Leaves	Vomiting, indigestions and dysentery.	Leave juice and eaten raw
				Fruit	Stomatitis and sore throat	Fruit juice
				Unripe fruit	Diarrhea	Eaten raw
13	*Murraya koenigii (L.) Spreng.*	Mitho Limbado	Rutaceae	Leaves	Digestive problems, diarrhea and vomiting	Eaten raw
14	*Ailanthus excelsa Roxb.*	Araduso	Simaroubaceae	Bark	Diarrhea	Bark decoction
15	*Balanties aegyptiaca (L.) Del.*	Ingoriyo	Balanitaceae	Fruit	Mouth ulcers	Bark extract
16	*Azadirachta indica A. Juss.*	Limbdo	Meliaceae	Root, Flower	Stomach ache	Extract in the form of powder
				Bark, Stem	Stomach ache, gastric problem, vomiting, dyspepsia, intestinal worm	As 'Ukalo'

17	*Soymida febrifuga A. Juss.*	Manu Rayanu / Royan	Meliaceae	Bark	Diarrhea, dysentery, general tonic, gargles	Bark extract and decoction
18	*Ziziphus xylopyrus (Retz.) Willd.*	Ghatbor	Rhamnaceae	Bark	Diarrhea	Bark extract
				Fruit	Diarrhea	Fruit decoction
19	*Mangifera indica L.*	Ambo / Keri	Anacardiaceae	Leaves	Diarrhea	Aqueous extract
20	*Spondias pinnata (L.) F.*	Ambado / Khatambhadu	Anacardiaceae	Leaves	Diarrhea	Leaf extract
21	*Moringa oleifera Lam.*	Saragavo / Mitho Saragavo	Moringaceae	Seeds	Digestive problems	Seed extract
22	*Butea monosperma (Lamk.) Taub.*	Khakhar / Kesudo	Fabaceae (Papilionaceae)	Bark	Stomatitis, cough, diarrhea, dysentery and ulcer	Gum of the bark
				Seeds	Ascaris and ringworm	Paste of seed
23	*Dalbergia latifolia Roxb.*	Sisam	Fabaceae (Papilionaceae)	Bark	Diarrhea	Bark extract
24	*Dalbergia sissoo Roxb.*	Sisoo	Fabaceae (Papilionaceae)	Bark	Dysentry	Bark extract / powder
25	*Pterocarpus marsupium Roxb. subsp. acuminatus (Prain) Thoth.*	Biyo	Fabaceae (Papilionaceae)	Bark, Wood	Gastric problems	Bark extract and decoction
				Leaves	Stomach pain and gastrointestinal disorders	Leaf extract
26	*Bauhinia purpurea L.*	Kanchnaar	Caesalpiniaceae	Bark	Diarrhea and ulcer	Bark decoction
27	*Bauhinia racemosa Lam.*	Aapto / Nano Ashitro	Caesalpiniaceae	Bark, Leaves	Diarrhea	Bark decoction
28	*Bauhinia malabarica Roxb.*	Nano Safed Ashitro	Caesalpiniaceae	Bark	Dysentry	Bark powder
29	*Cassia fistula L.*	Garmalo	Caesalpiniaceae	Fruit	Gastric problems and constipation	Fruit pulp
30	*Cassia siamea Lam.*	Kashid	Caesalpiniaceae	Seeds	Constipation	Seed powder
31	*Delonix regia (Boj. ex Hk.) Raf.*	Gulmahor	Caesalpiniaceae	Bark	Diarrhea	Bark extract
32	*Tamarindus indica L.*	Khati Ambali	Caesalpiniaceae	Bark	Diarrhea	Bark powder
				Fruit	Dyspepsia, gastritis, dysentery	Fruit pulp
33	*Acacia chundra (Roxb.) Willd.*	Kher	Mimosaceae	Bark	Diarrhea, dental pain and gastric problem	Bark decoction / powder
34	*Acacia farnesiana (L.) Willd.*	Tal Baval / Pilo Baval	Mimosaceae	Bark	Stomatitis	Bark decoction
35	*Acacia leucophloea (Roxb.) Willd.*	Harmo Baval / Samdi	Mimosaceae	Bark	Diarrhea, stomatitis	Bark extract
36	*Acacia nilotica (L.) Delile subsp. Indica (Benth.) Brenan.*	Deshi Baval / Ram Baval	Mimosaceae	Bark	Diarrhea	Bark extract in powder form
				Pods	Dysentry	Seed powder
37	*Albizia procera (Roxb.) Benth.*	Kilayi	Mimosaceae	Bark	Stomach ache	Bark decoction
38	*Anogeissus latifolia (Roxb. ex DC.) Wall. ex Bedd.*	Dhav / Dhavdo	Combretaceae	Bark	Diarrhea	Bark decoction
				Fruit	Diarrhea, dysentry	Fruit infusion or fruit powder
39	*Terminalia bellirica (Gaertn.) Roxb.*	Bahedo	Combretaceae	Fruit	Diarrhea, dyspepsia	Fruit powder
40	*Terminalia chebula Retz.*	Harade	Combretaceae	Fruit	Stomatitis, indigestion	Fruit powder
41	*Psidium guajava L.*	Jamfal	Myrtaceae	Fruit	Diarrhea, dysentry	Eaten raw
42	*Syzygium cumini (L.) Skeels.*	Jambu	Myrtaceae	Bark	Dysentry, stomach pain	Bark powder
				Fruit	Stomach complaints	Eaten raw or fruit infusion
43	*Syzygium salicifolium (Wight) J. Graham*	Jangali Jambu	Myrtaceae	Bark	Diarrhea, constipation	Bark powder
44	*Lagerstroemia lanceolata Wall.*	Hino / Nano Bondaro	Lythraceae	Root, Stem	Gastric pain and aphthae of the mouth	Infusion or decoction or powder
45	*Punica granatum L.*	Dadam	Punicaceae	Bark, Fruit	Digestive disorders	Bark powder and fruit eaten raw
46	*Adina cordifolia Hook. f. ex Brandis.*	Haldu / Haldaravo	Rubiaceae	Root	Diarrhea and dysentery	Root extract
				Bark	Vomiting, intestinal worms	Bark extract
47	*Gardenia resinifera Roth.*	Dikamali / Pendri	Rubiaceae	Bark, Gum	Vomiting and constipation	Bark extract and gum
48	*Neolamarckia cadamba (Roxb.) Bosser*	Kadamb / Krishna Kadamb	Rubiaceae	Bark	Diarrhea, vomiting	Bark extract

49	*Catunaregam spinosa (Thunb.) Tirveng.*	Mindhol / Mindhal	Rubiaceae	Leaves	Diarrhea, dysentry	Leaf extract
50	*Tamilnadia uliginosa (Retz.) Tirveng. & Sastre*	Gagada / Gangeda	Rubiaceae	Fruit	Diarrhea, dysentry	Eaten raw
51	*Manilkara zapota (L.) P. Royen*	Chiku	Sapotaceae	Bark	Diarrhea	Bark decoction
				Fruit	Diarrhea, dysentry, vomiting	Eaten raw
52	*Diospyros melanoxylon Roxb.*	Timru	Ebenaceae	Bark	Diarrhea	Bark extract
				Fruit	Stomach disorders	Eaten raw or fruit powder
53	*Holarrhena pubescens Wall. ex G. Don.*	Indrajav / Moti Kudi	Apocynaceae	Root	Diarrhea	Root extract
				Bark	Chronic diarrhea	Bark extract
54	*Wrightia tinctoria R. Br.*	Dudh Kudi	Apocynaceae	Leaves	Stomach pain, dysentry	Leaf infusion
55	*Cordia dichotoma G. Forst.*	Gunda / Vad Gundo	Ehretiaceae	Fruit	Worms and stomatitis	Eaten raw or pickled
56	*Oroxylum indicum (L.) Vent.*	Tetu	Bignoniaceae	Bark	Diarrhea	Bark powder
57	*Crescentia cujete L.*	Chandr Fal	Bignoniaceae	Fruit	Diarrhea, stomach ache	Fruit pulp and infusion
58	*Tectona grandis L.*	Saag	Verbenaceae	Bark	Dysentery, vomiting, loose motion, gastric problems	Bark powder
				Leaves	Dysentery, loose motion and vomiting	Leaf infusion or powder
59	*Santalum album L.*	Chandan	Santalaceae	Wood, Oil	Dysentry	Wood powder / paste and oil applied externally
60	*Emblica officinalis Gaertn.*	Aambla	Euphorbiaceae (Phyllanthaceae)	Fruit	Dyspepsia, bacillary dysentery, gastrointestinal tonic	Eaten raw
61	*Holoptelea integrifolia (Roxb.) Planch.*	Kokaranj / Kanjo	Ulmaceae	Leaves	Intestinal disorders	Leaf extract
62	*Artocarpus heterophyllus Lamk.*	Fanas	Moraceae	Root	Diarrhea	Root extract or infusion
				Leaves	Stomach ache	Leaf extract and powder
63	*Ficus carica L.*	Anjir	Moraceae	Fruit	Indigestion, loss of appetite, diarrhea	Eaten raw
64	*Ficus racemosa L.*	Umaro	Moraceae	Latex	Diarrhea	Used directly
65	*Ficus religiosa L.*	Pipalo	Moraceae	Fruit	Vomiting	Fruit infusion or eaten raw
66	*Cocus nucifera L.*	Nariyeli	Arecaceae (Palmae)	Fruit	Gastroenteritis	Eaten raw and its juice
67	*Phoenix sylvestris (L.) Roxb.*	Khajur	Arecaceae (Palmae)	Fruit	Vomiting	Eaten raw

Discussion

GI tract in animals, particularly humans, is one of the most vulnerable parts of body system and can significantly impact their health and well-being. The ailments of GI tract affect people of all ages, sexes and races. There has been raise in the Gastrointestinal System (GIS) disorders in the last decade. This raise may be due to the change in life style, lack of physical activity, improper nutrient intake, etc. Various physical and psychological conditions develop due to such disorders, like indigestion, diarrhea, depression, stress, impaired central nervous system functioning, anxiety, dysentery, etc. (Sperber et al. 2021 [43]; Chandran et al. 2019 [7]; Shah et al. 2014 [38]; Kanchibhotla et al. 2021) [22]. In India, the gastrointestinal disorder prevalence was observed to be ~18 % (Dawoodi et al. 2022) [12]. In developing countries like India, the increasing cost of health care significantly affects people's efficiency to afford health care and they generally avoid taking medical care. Hence, there is an immediate need to find ways to improve people's health care facilities with minimum cost and least or no side effects. India is rich in forest area with high floral diversity, and the indigenous knowledge about the traditional ways of using the plants for human benefits. The present study was one such attempt to publicize the knowledge of tribal communities related to medicinal utilization of plant species of Mandvi, Gujarat, India.

The medicinal tree species found in the forest area of Mandvi are highly diverse and have beneficial properties for treating the disorders related to the digestive system and alimentary canal. 67 medicinal tree species recorded during the study serves particularly the gastrointestinal ailments. The study revealed that 17 among the total species are rare and threatened in Mandvi, Gujarat.

Table 4: Rare and Threatened species in Mandvi. (in line with text)

Sr. No.	Rare and Threatened Tree Species	Sr. No.	Rare and Threatened Tree Species
1.	*Sterculia urens Roxb.*	10.	*Terminalia chebula Retz.*
2.	*Sterculia villosa Roxb.ex DC.*	11.	*Lagerstroemia lanceolata Wall.*
3.	*Spondias pinnata (L.) F.*	12.	*Adina cordifolia Hook. f. ex Brandis.*

4.	*Butea monosperma (Lamk.) Taub.*	13.	*Manilkara zapota (L.) P. Royen*
5.	*Dalbergia latifolia Roxb.*	14.	*Oroxylum indicum (L.) Vent.*
6.	*Pterocarpus marsupium Roxb.*	15.	*Santalum album L.*
7.	*Bauhinia malabarica Roxb.*	16.	*Emblica officinalis Gaertn.*
8.	*Albizia procera (Roxb.) Benth.*	17.	*Phoenix sylvestris (L.) Roxb.*
9.	*Terminalia bellirica (Gaertn.) Roxb.*		

The present study reported Caesalpiniaceae as the most species-rich family of all the families recorded, followed by Rubiaceae and Mimosaceae. The dominance in species percentage among the families by Caesalpiniaceae agrees with some previous studies (Mwakalukwa et al. 2014 [30]; Muthulingam & Thangavel 2012 [29]; Valencia et al. 1994 [50]; Bello et al. 2013) [2].

Various research studies and explorations are done to understand the traditional knowledge of medicinal properties of plants. However, such studies are undervalued and underfunded. A study reported 32 plant species at Wayanad district of Kerela curing GI disorders (Prasad et al. 2013) [36]. Such studies coincide with 33 plant species from Izmir province of Turkey, 36 species from Northern Thailand, and 40 medicinal plant species from Kishtwar plateau (J&K, India) (Dogan & Ugulu 2013 [14]; Tangjitman et al. 2015 [45]; Thakur et al. 2020) [46]. Similarly, current findings of 67 plant species in Mandvi Taluka indicates the richness of forests of Gujarat state having high diversity of medicinally important plant species. Among the total tree species reported, bark of 36 tree species formed a major group to treat GI ailments. Similar grouping based on the plant part used was also done by Raji tribe of Nepal (Thapa et al. 2013) [47]. Other major groups where leaves of 11 tree species, root of 6 species and seeds of 4 species. Other plant parts used where stem of 3 tree species, wood of 2 species, and gum, latex, pods, flowers and oil from single tree species. These parts are either used in raw form or were prepare into various formulations. Generally, fruits and leaves are parts used in raw form. All parts are also used in the form of extract, decoction, infusion, powder, juice, pulp, paste, etc. as per the need and effecting efficiency of the part used. Decoction and infusion are common methods used for bark utilization.

Ethnomedicinal surveys suggested the most prevalent GI disorder among the tribals were Diarrhea and Dysentery. Among the medicinally important species, 35 species were helpful in treating diarrhea, while 21 tree species were used for dysentery. The plant species most preferred for treatment of both these diseases where *Holarrhena pubescens Wall.* and *Helicteres isora L.* Bhoxa community of Dehradun district, Uttarakhand, also prefers the same plant species as reported by Gairola et al. (2013) [15]. Other prevalent GI disorders were general digestive problems, loss of appetite and vomiting, followed by various other disorders given in Table-2.

The quantitative analysis of vegetation showed high heterogeneity of trees in the forest of Mandvi. This interpretation was derived by classifying the 31 accessible tree species into Raunkiaer's frequency class. 83.87 % of those species (26 species) belonged to class 'A', suggesting greater heterogeneity and high species diversity. Density and relative density of *Tectona grandis L.* and *Acacia chundra (Roxb.) Willd.* were highest. These species were also observed to have high abundance and relative abundance. Most frequently recorded species in the study area during the study period were *Tectona grandis L.* and *Butea monosperma (Lamk.) Taub*. The vegetational quantitative analysis shows that this forest area is highly diverse with around 83.87 % heterogeneity (this may differ as many species were not accessible), and requires attention for learning and conserving the unique medicinal flora and their habitat. Most of these plant species are woody trees with a known threat to get cut down to obtain timber for economic benefit. The fruits of the trees are used as food source without the knowledge of its medicinal properties by many local inhabitants which somehow demeans it medicinal importance. The area might also face the problems of deforestation losing the valuable floral wealth in the near future. The area is majorly untouched by scientific community and there are many aspects yet to be studied and revealed.

Conclusions

The study recorded 67 plant species belonging to 55 genera and 32 families. They having medicinal properties serving in gastrointestinal ailments. They are used by tribals and local community for treating 14 to 20 GI ailments. Present study revealed the high dependency of tribals on the herbal medicinal flora and also the usefulness of medicinal properties of the wild plants. The plants might also possess the properties for treating various other ailments related to other body systems. This traditional knowledge needs to reach to modern healers and medical community. Also, there appears great opportunities for ethnobotanist to learn, understand and reveal various facets of relationship between plants and indigenous people. Botanist and pharmacologist can work together on the conservation and development of these medicinal plants for utilizing its healing properties for human benefits.

Declaration

List of Abbreviations: GI – Gastrointestinal, IVI - Importance value index, GIS – Gastrointestinal system, J&K – Jammu and Kashmir

Ethics approval and consent to participate: The current investigation did not involve the transportation of any plant specimens. The data were obtained from participants who willingly provided their information. Verbal consent was obtained from all informants prior to their participation.

Consent for publication: All authors have read the manuscript and agree for its publication.

Availability of data and materials: The manuscript encompasses complete information.

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Conflict of Interests
The authors declare that there are no conflicts of interest related to this article.

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