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Cultural ethnobotany and urban biodiversity in an eco-friendly *Rakhi*-making initiative in Rajasthan, India

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Abstract. *Jain V. 2025. Cultural ethnobotany and urban biodiversity in an eco-friendly* Rakhi-*making initiative in Rajasthan, India. Asian J Ethnobiol 8: 245-257.* Festivals are integral to the culturally rich Indian subcontinent. Rakshabandhan (*Rakhi*), celebrated on *Shravani Purnima*, is a unique traditional Indian festival symbolizing the bond of trust between siblings, where sisters tie a sacred thread on their brother's wrists. To promote eco-consciousness and the use of sustainable materials in traditional crafts, an eco-friendly *Rakhi*-making competition was organized in August 2024 by the Department of Botany, Government Meera Girls College, Udaipur, Rajasthan, India, in which 23 female students (mean age = 20.65 years) participated. An ethnobotanical survey through participant interviews and field observation was conducted to document the plant-based materials used. A total of 53 plants (13 wild and 40 cultivated) belonging to 28 families were employed to prepare various *Rakhi* by the participants. Among these, 44 Dicotyledon, 8 Monocotyledon, and 1 Gymnosperm plant were observed. Fabaceae was the most represented family, followed by Apocynaceae, Poaceae, Asteraceae, and Euphorbiaceae. Floral parts were maximally utilized, followed by seeds, leaves, fruits, roots, and stems. The highest Relative Frequency of Citation (RFC) was recorded for *Vigna radiata* (0.35), *Oryza sativa* and *Rosa* spp. (0.30 each), indicating easy accessibility of these plant materials. Notably, *Platycladus orientalis* and *Pistacia vera* used in this competition are listed as Near Threatened in the IUCN Red Data List, highlighting the need for conservation efforts. This initiative showcases the creative integration of traditional knowledge and sustainability and suggests that such competitions can inspire ethnobotany-based entrepreneurship, while fostering ecological awareness and cultural values among students.

Keywords: Cultural ecology, festival, non-timber forest products, urban biodiversity, urban ethnobotany, youth innovation

INTRODUCTION

Festivals, as part of human culture, reflect creativity, spirituality, and unity. They are celebrated for faith and religious purposes and also for marking change in seasons, the country's important days, or to showcase the art, craft, music, dance, or the tradition of a particular community. They act as catalysts for social cohesion and community engagement, create employment opportunities, and boost tourism (Owano and Nyamanga 2024). Rituals embedding traditional wisdom are an important part of many of the festivals and have long been recognized as powerful conduits of cultural expression and identity formation.

In India, several traditional festivals are celebrated across the entire country, among which Diwali, Holi, and *Rakhi* (Rakshabandhan) are prominent ones (Lata et al. 2022). *Rakhi* is celebrated every year on *Shravani Purnima*, i.e., full moon day of Shravan month (as per the Hindu calendar), which usually falls in August on different dates as per the English calendar. This festival is known for the bonding between a brother and sister, where a sister ties a thread in the form of a beautiful *Rakhi* (*Raksha sutra*) on the wrist of his brother in demand of protection. Brother, vows on this occasion to take care of his sister and protect her from evil forces. This act is not merely ceremonial; it exemplifies how rituals reinforce social ties and serve as living embodiments of cultural meaning and emotional identity (Karle et al. 2025). Usually, *Rakhi* is prepared from the cotton/silk-cotton or synthetic fiber thread, plastic, any metal (silver/gold/brass/aluminum/copper/iron), and other decorative items. Fifteen days before the occurrence of the festival, stalls containing different varieties of *Rakhi* are displayed in the markets of both rural and urban areas. The *Rakhi* is often costly and, unfortunately, non-biodegradable, raising environmental concerns.

Ethnobotany is the study of all kinds of relationships existing between plants and people including use of plants for various cultural traditions, festivals, and rituals (Jigme and Yangchen 2022; Lata et al. 2022; Ma et al. 2024). In fact, valuable botanical insights could be obtained through ethnobotanical investigations of festival-related practices within specific communities (Franco and Robin 2011). For example, Lata et al. (2024) documented the use of 47 plants for the celebration of Fulaich (festival of flowers) by Kinnaura tribes in Himachal Pradesh, India. Mukarromah et al. (2024) reported the use of 27 Angiosperm plants in 10 traditional festivals celebrated in three villages of Surakarta City, Central Java Province, Indonesia. Moreover, traditional ecological knowledge is also shown in various rituals and daily cultural practices (Ma et al. 2024). Ethnobotanical studies are therefore, essential to find out that how human beings interact with plants and what roles are played by plants in human life.

Rajasthan is the largest state of India as per area, with 13.48% scheduled tribal population of its total population (Population Census Data 2025). Udaipur city, situated in

South Rajasthan, is a well-known tourist city on the world map, situated at a latitude of 24.5854° North and a longitude of 73.7125° East. Various traditional fairs and festivals are vibrantly celebrated all year round in Udaipur city, for example, *Holi, Basoda, Dasha Mata, Gangaur, Rakhi, Hariyali Amavasya, Navratri, Diwali*, etc. Ethnobotanical investigations to some of these have revealed that a number of plants are related to these festivals in different forms. Kunwar and Jain (2021) recorded the use of 23 Angiosperm plants in traditional fairs organized on *Hariyali Amavasya* and *Sakhiya Somwar* in Udaipur, Rajasthan. However, the use of plants in various cultural expressions that formulate the culture-based man-plant relationships is hitherto less explored among the ethnobotanical studies carried out so far in Rajasthan, India. The studies reporting different plants used for various arts and crafts are also scanty.

In view of all these, traditional festivals can be harnessed as powerful platforms for promoting eco-conscious, culturally rooted, and sustainable practices. As *Rakhi* is a well-known traditional Indian festival celebrated by using several synthetic items for making the sacred thread, an attempt was made to promote eco-consciousness among the youth to celebrate it sustainably. With this in mind, for the first time, an eco-friendly *Rakhi* competition was organized on Friday, 16 August 2024, in view of the forthcoming *Rakhi* festival (19 August 2024), for the students affiliated to the Department of Botany, Government Meera Girls College, Udaipur, Rajasthan, India. Earlier, such competitions were held in Punjab, Maharashtra, and New Delhi, India. In this competition, girls were given a task to prepare and bring an eco-friendly *Rakhi* (made from eco-friendly materials, especially plants), which was displayed in the Department of Botany for faculty members of all Departments of the College. The location map from where the students collected the plants to prepare *Rakhi* is given in Figure 1. The objective of this study was to document the plant diversity that young people used to prepare *Rakhi*, as well as to explore the culture-based relationships between people and plant that emerged from the eco-friendly *Rakhi* competition.

MATERIALS AND METHODS

An ethnobotanical survey of the above-mentioned eco-friendly *Rakhi*-making competition organized at the Government Meera Girls College, Udaipur, India, was carried out through observation and interview of participants (n=23) on 16 August 2024.

Procedural details

Prior informed consent was obtained from the participants before taking the interview and photographs. Also, the objectives and process of this study were explained to them before conducting the survey. The competition was conducted with prior permission of the institute, but there was no need for ethical approval to conduct such a study. Interviews were taken from 23 girls who participated in the competition, with code numbers given to them. To keep the privacy, the first and middle names of the participants are abbreviated in Table 1. All the students were asked to provide a list of plant materials that they used to prepare the *Rakhi*. Queries, for example, from where did they get the various plant materials, from where did they get the idea of preparing such a kind of *Rakhi*, what motivated them to use a particular plant for *Rakhi*, the local name of the plant used if any, the preference of wild v/s cultivated plants for making *Rakhi*, etc., were also asked to them. Digital documentation of the eco-friendly *Rakhi* prepared by them was also done through capturing images; some of which have been shown in Figure 2.

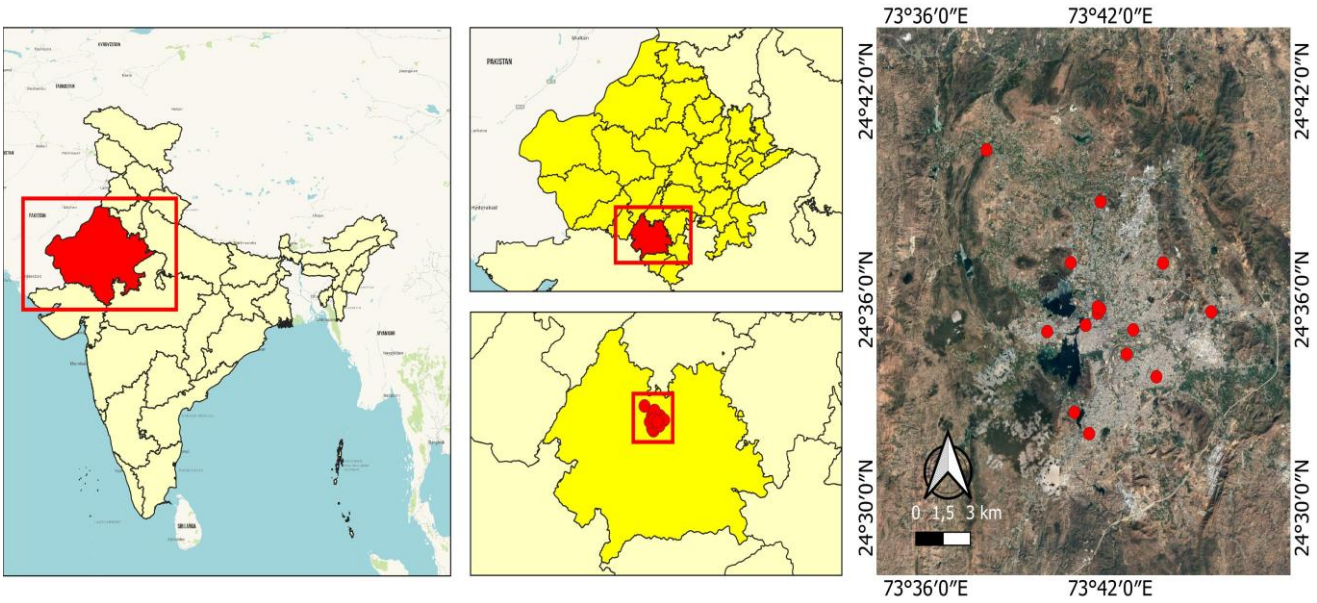

Figure 1. Location map of plant collection zones for the preparation of eco-friendly *Rakhi*

Table 1. Details of the participants in the eco-friendly *Rakhi*-making competition

Name of the student	Class	Area of plant collection	Age (years)	Code no.
D. Sharma	M.Sc. Botany IV Semester	Kankroli, Rajsamand	23	1
R. Gupta	M.Sc. Botany IV Semester	Madhuban, Udaipur	23	2
Y. Yadav	M.Sc. Botany IV Semester	Bicchiwada, Dungarpur	24	3
P. Dhakad	M.Sc. Botany IV Semester	Madhuban, Udaipur	24	4
M. Banu	M.Sc. Botany IV Semester	Nathdwara, Rajsamand	23	5
T. K.Chundawat	B.Sc. III Year	Chitrakoot Nagar, Udaipur	20	6
R. K. Chundawat	B.Sc. III Year	Chitrakoot Nagar, Udaipur	20	7
M. Khan	B.Sc. II Semester	Sajjan Nagar, Udaipur	18	8
R. Meghwal	B.Sc. II Semester	Bedla, Udaipur	18	9
K. Ganchha	B.Sc. II Semester	Madhuban, Udaipur	18	10
H. Sanadhya	B.Sc. II Semester	Shreenathji temple, Hathipole, Udaipur	17	11
C. Maurya	B.Sc. II Semester	Near RTO, Pratapnagar, Udaipur	18	12
A. Siddiq	B.Sc. II Semester	Mullatalai, Udaipur	18	13
G. Lohar	M.Sc. Botany II Semester	Shiv Nagar, Sec. 14, Udaipur	21	14
N. Kumawat	M.Sc. Botany II Semester	Neemach Kheda, Udaipur	20	15
J. Kumari	M.Sc. Botany II Semester	Madhuban, Udaipur	22	16
K. Choudhary	M.Sc. Botany II Semester	College campus, Udaipur	21	17
G. Vaishnav	M.Sc. Botany II Semester	Dangiyon ki Hundar, Madar, Udaipur	21	18
S. Jat	M.Sc. Botany II Semester	Residency Road, Udaipur	21	19
P. K. Daroga	M.Sc. Botany II Semester	Mali colony, Udaipur	22	20
L. Chawla	B.Sc. III Year	Mulla Talai, Gandhi Nagar, Udaipur	20	21
M. Menaria	M.Sc. Botany II Semester	Gayatri Nagar, Sec. 5, Udaipur	23	22
P. Suthar	B.Sc. III Year	Chitrakoot Nagar, Udaipur	20	23

Figure 2. Various eco-friendly *Rakhi* was displayed in the competition held at the Government Meera Girls College, Udaipur, India. A. Code No. 01, B. Code No. 02, C. Code No. 05, D. Code No. 09, E. Code No. 11, F. Code No. 12, G. Code No. 15, H. Code No. 16, I. Code No. 17, J. Code No. 18, K. Code No. 21, L. Code No. 20, M. Code No. 22, N. Code No. 23

Data analysis

After observing the eco-friendly *Rakhi* prepared by the participants carefully for obtaining the details of plant species utilized, the plants were identified using Flora of Rajasthan (Shetty and Singh 1987-1993), and a recent updated botanical nomenclature was adopted for all the plant species (POWO 2025). For the correct identification of some of the plant species, pictures of those plants were also procured from their original collection sites.

Descriptive statistics were used to analyze the life form, plant part used, dominant botanical families, wild/cultivated status, source of collection of the plant material, and exotic plant numbers. The obtained data were pursued for further analysis using a quantitative ethnobotanical index known as Relative Frequency of Citation (RFC). It is calculated by dividing the number of informants who used a particular species by the total number of informants who participated in the study. Usually, it ranges from zero to one. Near-zero values suggest that only a few persons use the particular species, and higher values indicate that more persons are using that particular species for the same purpose (Tardío and Pardo-de Santayana 2008).

All the plants are enumerated alphabetically with their botanical name and family, common and local name, habit, part used, code number, and relative frequency of citation in Table 2. The database available on Plants of the World Online (POWO 2025) was checked to find out the nativity of each plant species, and details of exotic plant species are given in Table 3. To know the conservation status of each plant, the IUCN Red List was thoroughly checked (IUCN 2025), and the findings are discussed in the next section. Besides, an attempt was made to analyze the results of the study in context with UN Sustainable Development Goals (United Nations 2025) and National Education Policy-2020 (Ministry of Human Resource Development Government of India 2025).

RESULTS AND DISCUSSION

Details of participants in the *Rakhi* competition

All the participants were females of young age (Mean age = 20.65 years). Ten girls were studying in an Undergraduate course (Four in the Final year and six in the Second semester of a three-year degree course). The remaining 13 girls were enrolled in a Postgraduate course (a two-year degree course), i.e., Master's in Botany (Five in Fourth semester and Eight in Second semester), offered by the college. Two girls prepared eco-friendly *Rakhi* at Rajsamand and one at Dungarpur district; both districts have adjoining boundaries with Udaipur District. The remaining 20 girls prepared *Rakhi* at their homes situated in various localities of Udaipur city and brought them to the college for participation in the competition (Table 1). About 80% girls revealed that the reason behind choosing a particular plant was primarily easy availability in their homes. The rest of the girls were told that there was no specific reason behind the selection of a particular plant for the preparation of *Rakhi*.

This competition was organized for the first time in Rajasthan, India, and no such event has been organized in Udaipur till now. The gender bias in this study is due to the belonging of all the participants to an exclusively girls' college. This may have influenced the material preference, aesthetic choice, and crafting techniques, as cultural expectations are usually associated with females who have prior experience with craft-based activities. If the study had included male participants, the plant selection would have been different. Moreover, all the participants were studying Botanical sciences; thus, having better knowledge of plants and overall biodiversity, as well as more awareness about ecology. This scientific background could lead to an academic bias in plant selection instead of community-based ethnobotanical practices. On the other hand, unequal access to plant materials depending on the location (urban/rural) and the socio-economic status of participants could also skew the results. Use of more visually attractive plant material, irrespective of their ecological or traditional relevance, could have affected the study results. These biases reflect the significance of diverse participants' inclusion, collaboration across disciplines, and the correct interpretation of ethnobotanical information in context. Therefore, the present findings could be expanded and further validated with larger research incorporating wider demographics in future such events.

Cataloguing of plants used for the preparation of *Rakhi*

The ethnobotanical investigation revealed that students utilized 53 plant species (51 genera) belonging to 28 families for the preparation of eco-friendly *Rakhi* (Table 2). Two genera, namely, *Jasminum* and *Vigna,* among 51, contributed the maximum species (2 each). Among the 53, 44 plants (23 families) were Dicotyledons, and 8 plants (4 families) were Monocotyledons of Angiosperms. The dominance of Dicot plants (23 families) was also observed in another ethnobotanical study by Mohanty et al. (2025), where 47 plants were documented for use in various rituals practiced among people of Jajpur district, Odisha, India. This distribution aligns with global plant diversity patterns, where dicots are more commonly used in traditional and cultural practices due to their diverse leaf and flower forms. One plant, *Platycladus orientalis*, whose leaves were utilized to decorate the *Rakhi*, was a Gymnosperm demonstrating that non-flowering plants could not be excluded entirely if aesthetically observed as useful. The analysis of plant families revealed that the dominant families were Fabaceae (8 plants), followed by Apocynaceae and Poaceae, each with 5 plants, Asteraceae and Euphorbiaceae, each with 4 plants, Malvaceae (3 plants), and Cucurbitaceae and Oleaceae, each with 2 plants. The rest of the 20 families were represented by only one plant species (Figure 3).

Table 2. Plants are utilized for making eco-friendly *Rakhi* in the competition

Botanical name & family	Common and local name	Habit	Part used	Source	Plant collection site	Code no.	RFC
Abelmoschus esculentus (L.) Moench (Malvaceae)	Okra, Bhindi	Herb	Fruit	Cultivated, Non-native	Market	09	0.04
Bergera koenigii L. (Rutaceae)	Curry Leaf, Kadhi Patta	Tree	Dried leaves	Cultivated, Native	Home Garden	13	0.04
Bougainvillea spectabilis Willd. (Nyctaginaceae)	Great Bougainvillea	Shrubby vine	Flower	Cultivated, Non-native	College Campus Garden	19	0.04
Brassica juncea (L.) Czern. (Brassicaceae)	Indian Mustard, Rai	Herb	Seed	Cultivated, Non-native	Market	22	0.04
Butea monosperma Kuntze (Fabaceae)	Bastard Teak, Khakara	Tree	Leaves	Wild, Native	Roadside	11	0.04
Cajanus cajan (L.) Huth (Fabaceae)	Pigeon Pea, Arhar	Herb	Split seed	Cultivated, Native	Market	09, 21	0.09
Calotropis procera (Aiton) W.T.Aiton (Apocynaceae)	Apple Of Sodom, Aak	Shrub	Flower	Wild, Native	Roadside	20	0.04
Camellia sinensis (L.) Kuntze (Theaceae)	Tea, Chai	Shrub	Dried leaf powder	Cultivated, Native	Market	02	0.04
Cascabela thevetia (L.) Lippold (Apocynaceae)	Yellow Oleander, Peeli Kaner	Tree	Floral part	Cultivated, Non-native	College Campus Garden	02, 04, 14	0.13
Catharanthus roseus (L.) G.Don (Apocynaceae)	Madagascar Periwinkle, Sadabahar	Herb	Leaves, Flower	Cultivated, Non-native	College Campus Garden	18, 20	0.09
Cicer arietinum L. (Fabaceae)	Gram, Chana	Herb	Split seed	Cultivated, Non-native	Market	02, 04, 09, 19, 20	0.21
Combretum indicum (L.) DeFilipps (Combretaceae)	Rangoon Creeper, Madhumalti	Climber	Flower	Cultivated, Non-native	College Campus Garden	10	0.04
Cosmos sulphureus Cav. (Asteraceae)	Orange Cosmos	Herb	Flower	Cultivated, Non-native	College Campus Garden	07, 16	0.09
Cynodon dactylon (L.) Pers. (Poaceae)	Bermuda Grass	Herb	Leaf	Wild, Non-native	Roadside	07, 15	0.09
Echinochloa colonum (L.) Link (Poaceae)	Indian Barnyard Millet, Sama	Herb	Seed	Cultivated, Native	Market	02	0.04
Elettaria cardamomum (L.) Maton (Zingiberaceae)	Cardamom, Ilayachi	Herb	Outer shell of fruit, complete fruit	Cultivated, Native	Market	01, 05	0.09
Euphorbia thymifolia L. (Euphorbiaceae)	Gulf Sandmat, Chhota Dudhi	Herb	Leaves	Wild, Non-native	Roadside	23	0.04
Glycine max (L.) Merr. (Fabaceae)	Soyabean	Herb	Seed	Cultivated, Non-native	Market	12	0.04
Gossypium spp. (Malvaceae)	Cotton, Rui	Tree	Seed-hair fibre	Cultivated, Native	Market	11, 18, 21, 23	0.17
Illicium verum Hook.fil. (Schisandraceae)	Star Anise, Chakari Phul	Tree	Dried fruit	Cultivated, Non-native	Market	05	0.04
Ipomoea quamoclit L. (Convolvulaceae)	Cypress Vine	Climber	Flower	Cultivated, Non-native	Roadside	10	0.04
Ixora coccinea L. (Rubiaceae)	Jungle Geranium	Shrub	Flower	Cultivated, Native	College Campus Garden	17	0.04
Jasminum officinale L. (Oleaceae)	Common Jasmine, Chameli	Shrub	Flower bud	Cultivated, Native	College Campus Garden	08, 10, 16, 17	0.17
Jasminum sambac (L.) Aiton (Oleaceae)	Jasmine, Mogra	Shrub	Flower bud	Cultivated, Native	College Campus Garden	08, 11, 14	0.13
Jatropha integerrima Jacq. (Euphorbiaceae)	Peregrina	Shrub	Flower	Cultivated, Non-native	Home Garden	15, 22	0.09
Lantana camara L. (Verbenaceae)	Lantana	Shrub	Flower	Wild, Non-native	Roadside	16, 17	0.09
Mallotus philippensis (Lam.) Müll.Arg. (Euphorbiaceae)	Kamala Tree, Kumkum	Tree	Fruit powder	Wild, Native	Home Garden	18	0.04
Malvastrum coromandelianum (L.) Garcke (Malvaceae)	False Mallow, Kharenti	Herb	Leaves	Wild, Non-native	Roadside	03, 18	0.09
Manihot esculenta Crantz (Euphorbiaceae)	Tapioca Sago, Sabudana	Herb	Seed	Cultivated, Non-native	Home Garden	15	0.04
Momordica dioica Roxb. ex Willd. (Cucurbitaceae)	Spiny Gourd, Kikoda	Climber	Fruit	Wild, Native	Roadside	09	0.04

Musa × *paradisiaca* L. (Musaceae)	Banana, Kela	Herb	Leaves	Cultivated, Non-native	Home Garden	11	0.04
Nerium oleander L. (Apocynaceae)	Oleander, Kaner	Tree	Flower	Cultivated, Non-native	Home Garden	08	0.04
Oryza sativa L. (Poaceae)	Rice, Chawal	Herb	Seed	Cultivated, Non-native	Market	03, 05, 06, 07, 18, 19, 20	0.30
Parthenium hysterophorus L. (Asteraceae)	Congress Grass, Gajar Ghas	Herb	Flower	Wild, Non-native	Roadside	17	0.04
Phaseolus vulgaris L. (Fabaceae)	Kidney Bean, Rajma	Herb	Seed	Cultivated, Non-native	Market	12	0.04
Phoenix dactylifera L. (Arecaceae)	Date Palm, Khajur	Tree	Leaf	Wild, Non-native	Roadside	06, 07, 23	0.13
Phyllanthus emblica L. (Phyllanthaceae)	Indian Gooseberry, Amla	Tree	Leaves	Cultivated, Native	Home Garden	18	0.04
Piper nigrum L. (Piperaceae)	Black Pepper, Kali Mirch	Climber	Dried fruit	Cultivated, Native	Market	06, 12, 13, 15, 20, 23	0.26
Pistacia vera L. (Anacardiaceae)	Pistachio, Pista	Tree	Outer shell	Cultivated, Non-native	Market	04, 06, 13, 21, 23	0.21
Platycladus orientalis (L.) Franco (Cupressaceae)	Oriental Thuja, Morpankhi	Tree	Leaves	Cultivated, Non-native	College Campus Garden	10, 22	0.09
Plumeria alba L. (Apocynaceae)	White Frangipani, Champa	Tree	Flower	Cultivated, Non-native	College Campus Garden	20	0.04
Portulaca grandiflora Hook. (Portulacaceae)	Rose Moss	Herb	Flower	Cultivated, Non-native	College Campus Garden	14	0.04
Rosa spp. (Rosaceae)	Rose, Gulab	Shrub	Flower, leaves	Cultivated, Native	Home Garden	08, 10, 11, 14, 17, 19, 20	0.30
Syzygium aromaticum (L.) Merr. & L.M.Perry (Myrtaceae)	Clove, Laung	Tree	Dried flower buds	Cultivated, Non-native	Market	01, 05, 06, 07, 20	0.21
Tagetes erecta L. (Asteraceae)	Mexican Marigold	Herb	Flower	Cultivated, Non-native	Home Garden	11	0.04
Tinospora cordifolia (Willd.) Hook.fil. & Thomson (Menispermaceae)	Heart-Leaved Moonseed, Giloy	Climber	Root	Wild, Native	Roadside	04	0.04
Trichosanthes cucumerina L. (Cucurbitaceae)	Snake Gourd, Chichinda	Climber	Stem	Wild, Native	Roadside	02	0.04
Tridax procumbens L. (Asteraceae)	Coatbuttons	Herb	Flower	Wild, Non-native	Roadside	14	0.04
Triticum aestivum L. (Poaceae)	Wheat, Gainhu	Herb	Flour, Seed	Cultivated, Native	Market	15, 21	0.09
Vicia lens (L.) Coss. & Germ. Syn. *Lens culinaris* Medik. (Fabaceae)	Lentil, Masur	Herb	Split seed	Cultivated, Non-native	Market	05, 09, 12, 19	0.17
Vigna mungo (L.) Hepper (Fabaceae)	Black Gram, Urd Bean	Herb	Split seed, whole seed	Cultivated, Native	Market	02, 04, 07, 20, 21	0.21
Vigna radiata (L.) R.Wilczek (Fabaceae)	Green Gram, Mung Bean	Herb	Split seed, whole seed	Cultivated, Native	Market	02, 03, 04, 07, 12, 15, 20, 21	0.35
Zea mays L. (Poaceae)	Maize, Makai	Herb	Spathe, seed	Cultivated, Non-native	Market	05, 06	0.09

Note: RCF: Relative Frequency of Citation

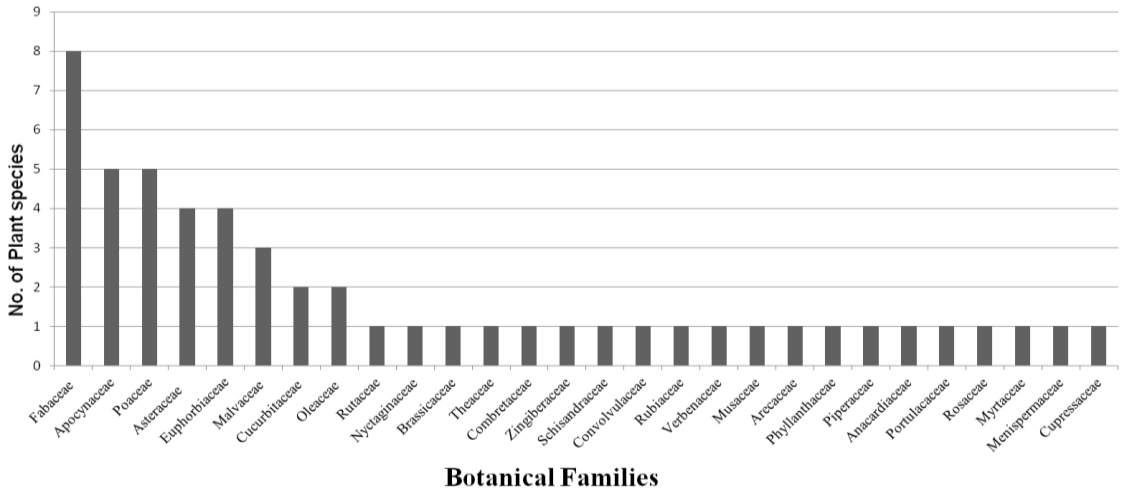

Figure 3. Distribution of 53 plants used for *Rakhi* preparation in botanical families

As most of the pulses belonging to the family Fabaceae are easily available in Indian kitchens, it might be the reason behind its dominance in the study where students utilized plants available in their vicinity for preparing *Rakhi*. Fabaceae was also the most widely used botanical family among 25 plants used for the treatment of various ailments by the Damor tribe in Simalwara, Dungarpur, Rajasthan (Shrimali et al. 2021). Plants of the second dominant family, Apocynaceae, were common ornamentals having fragrant flowers, and Poaceae family grains were preferred for easy availability and symbolic purposes, such as Wheat and Rice. However, the dominance of a few botanical families in the study possibly indicates limited knowledge of lesser-known useful species available in their surroundings, or cultural preference and ecological abundance of certain plant species.

Ethnobotanical sciences contribute not only to agricultural innovation, building plant-based products, or to the health industry, but also have a deeper understanding of ecological knowledge, which helps in better management of landscapes and resources. Traditional Ecological Knowledge (TEK) can play a crucial role in contemporary biodiversity conservation and sustainable development. In fact, the biocultural approach that integrates cultural values and local knowledge in the sustainable use of plant diversity could be useful for future conservation and developmental policymaking (Pei 2013). In view of this, the eco-friendly *Rakhi*-making initiative in Udaipur serves as an innovative ethnobotanical intervention through the utilization of over 50 plant species in *Rakhi*-making, uncovering the layers of TEK embedded in material selection, symbolism, and cultural storytelling. Recently, Marín et al. (2024) reported 65 taxa that were utilized to make sculptures and other architectural grains in annual Agricultural fairs at Baix Llobregat (Catalonia, NE Iberian Peninsula). Chiocchio et al. (2024) carried out an extensive ethnobotanical study in the Bologna district in Northern Italy. They documented the use of 32 plant taxa for various craft work as reported by 1172 informants. The present study explores similar dimensions of plants that were used for artistic purposes for the celebration of the *Rakhi* festival in a sustainable way. In fact, such events help activate local knowledge systems and adapt them to modern environmental concerns. Additionally, this initiative has built a living archive of ethnobotanical knowledge that might otherwise be lost due to globalization and synthetic consumer products. By combining traditional plant use with modern educational efforts, it shows how ethnobotanical knowledge can be actively preserved and reinterpreted.

Besides, from an environmental perspective, this initiative recasts the material economy of goods available for festivals. It substitutes locally-sourced, biodegradable, and renewable materials for synthetic threads, plastics, glitters, and foils. This shift encourages a circular economy based on natural cycles and low-carbon alternatives. In terms of education, it helps the participants, especially young people, to develop a value-based sustainability perspective by exposing them to the connections between ethics, the environment, and culture. It transforms *Rakhi*-making from a mere craft into a pedagogical tool for sustainability education, as well as promoting mindfulness in material use and cultural practice.

Growth habit and plant part used

The life form of these plants exhibited that 47% are Herbs (n=25), 25% are Trees (n=13), 15% are shrubs (n=8), and 13% (n=7) were climbers (Figure 4). Use of climbers was done for making a tying thread for *Rakhi*, whereas herbs were used for their easy access, soft texture, and flexible properties. The floral parts of these 53 plants were among the most used parts, followed by seeds, leaves, fruits, roots, and stems. An ethnobotanical study carried out by Lata et al. (2024) also reported maximum use of the floral part, followed by leaves, seeds, and twigs of 47 plants used for the celebration of the festival of flowers in Himachal Pradesh, India. Color, fragrance, and symbolic value could be the main reasons behind the maximum use of the floral parts of the plant species reported in the present study. Each plant part has different implications for sustainability and cultural acceptability, which is useful to assess the ecological impact of such eco-friendly

initiatives. Harvesting of flowers from seasonal blooms or cultivated species for rituals or decoration is often regulated by some customary practices that avoid overharvesting. However, continuous flower collection from wild populations in ecologically sensitive areas may disrupt the reproductive cycle of the plant and overall jeopardize its survival. Leaves and seeds, on the other hand, are relatively renewable resources, and their collection would have a low ecological impact. For example, the use of seeds from cultivated crops having high RFC values (*Oryza sativa* and *Vigna radiata*) poses minimal sustainability concerns. Moreover, the limited use of destructive parts (stem and roots) for *Rakhi*-making in the present study could be an important approach to achieve sustainability and signifies the deeper ecological understanding of participants.

Notably, two plant parts of the same plant were also used for making *Rakhi*, for example, *Catharanthus roseus, Rosa* spp., and *Zea mays* (Table 2). Incorporating multiple plant parts from the same species reflects a deeper understanding of plant morphology and possibly more culturally acceptance of the plant species. This also exhibits a rather multi-functional approach used by students, possibly to reduce waste or to enhance visual perception. Overall, the predominance of herbs and floral parts in *Rakhi*-making underscores a preference for materials that are aesthetically appealing, easy to handle, and culturally significant.

Native v/s exotic plants used for the preparation of *Rakhi*

Exotic species are those that move outside their native distributional range due to accidental or anthropogenic reasons and usually considered to have negative ecological impact. However, it is not always necessary. Exotic species may flourish in their non-native sites either due to deliberate cultivation by man or due to their excessive invasiveness. Impact of exotic flora on traditional knowledge is usually considered to be negative, but studies have shown the adaptive nature of indigenous knowledge systems (Gama et al. 2018). For example, exotic species have entered into indigenous pharmacopeia of Shurugwi in South-central Zimbabwe (Maroyi 2018). Jain and Jain (2020) reported the use of exotic plant species for worship/temple decoration purposes from Udaipur, India. This indicates the adaption of exotic plants by local communities. In this regard, the present study revealed that out of 53 species, 60% of the plants used by participants to prepare eco-friendly *Rakhi* were not native to India. These plant species were introduced to India from other countries such as North and South America, Africa, China, Middle East and South East Asia (Table 3). *Rosa* spp. is also included in the list of exotic plants, which makes the total count 32. Besides the exotic crop plants and vegetables, *Brassica juncea, Abelmoschus esculentus, Cicer arietinum, Glycine max, O. sativa, Phaseolus vulgaris, Vicia lens,* and *Z. mays,* as well as spices and nuts, such as *Illicium verum, Pistacia vera,* and *Syzygium aromaticum*, all other exotic species were well known for their beautiful appearance as flowers and mostly grown for ornamental purposes along with other native plants of India. This exhibits the intermingling of native and non-native flora, creating an opportunity to integrate with knowledge of local communities, which was reflected in using these plants for making *Rakhi*. Patil (2024) documented the use of 51 alien Angiosperm plant species for the worship of goddess Durga during the traditional Durga Puja festival in various Indian states. Notably, among them, nine exotic plants, namely, *Cascabela thevetia, Cynodon dactylon, Combretum indicum, Hibiscus rosa-sinensis, Jasminum sambac, Nerium indicum, Tabernaemontana divaricata, Tagetes erecta* and *Triticum aestivum* used for worship purpose (Patil 2024) are also common in the present study revealing their cultural and religious significance and acceptance in India. Similarly, five exotic plants out of 47, namely, *C. thevetia, H. rosa-sinensis, Lantana camara, N. indicum* and *P. alba* used by Soliga tribes for socio-cultural purposes in Anthiyur Taluk, Erode District, Tamil Nadu, India (Menaka et al. 2025) are also observed in the current study for making eco-friendly *Rakhi*.

The cultural intricacy of the floral diversity has been explored earlier in South Rajasthan by several scientists. For example, floral *Rakhi* from flowers of *L. camara* and *Leucas aspera* are prepared by tribal girls to celebrate the *Rakhi* festival (Jain and Sharma 2015). A study at Maputaland-Pondoland-Albany biodiversity hotspot, South Africa reported varying degree of cultural assimilation for 17 invasive shrub and tree species highlighting their amalgamation among daily lives of local people (Wootton and Shackleton 2023). Notably, in the present study, the use of flowers of invasive plant species, namely, *Parthenium hysterophorus* and *L. camara,* was also observed for making *Rakhi*. It shows that the abundance of these invasive species among native flora is making their cultural integration more accessible in the community. Although *L. camara* and *P. hysterophorus* are non-native to India and considered invasive due to their detrimental ecological impact but they now grow widely in the wild. Their use for cultural purpose indicates that the cultural distinction between native/wild/invasive is now being blurred. Further, this cultural assimilation of invasive flora in traditional crafts reveals how human creativity and cultural practices evolve in changing ecological landscapes.

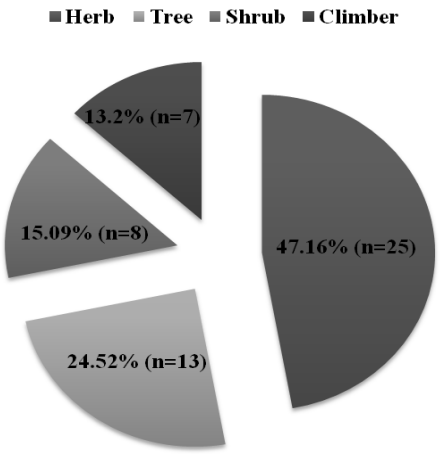

Figure 4. Percentage of growth forms of plants used for the eco-friendly *Rakhi* competition

Table 3. Exotic plant species used for making eco-friendly *Rakhi*

Name of plant	Nativity
Abelmoschus esculentus (L.) Moench	Tropical Africa
Bougainvillea spectabilis Willd.	Brazil
Brassica juncea (L.) Czern.	Tibet
Cascabela thevetia (L.) Lippold	Tropical America and the West Indies
Catharanthus roseus (L.) G.Don	West Indies and Madagascar
Cicer arietinum L.	Iran, Iraq, Türkey
Combretum indicum (L.) DeFilipps	Burma, Malaya, New Guinea
Cosmos sulphureus Cav.	Mexico to Central America
Euphorbia thymifolia L.	Tropical America
Glycine max (L.) Merr.	Eastern Asia
Illicium verum Hook.fil.	China Southeast
Ipomoea quamoclit L.	Tropical America
Jatropha integerrima Jacq.	Cuba
Lantana camara L.	Tropical America
Malvastrum coromandelianum (L.) Garcke	South America
Manihot esculenta Crantz	Tropical America
Musa × *paradisiaca* L.	Malaya, Philippines
Nerium indicum Mill.	China
Oryza sativa L.	China
Parthenium hysterophorus L.	West Indies, Central and North America
Phaseolus vulgaris L.	South America, Mexico
Phoenix dactylifera L.	Gulf States, Iran, Iraq, Oman
Pistacia vera L.	Afghanistan, Iran, Kazakhstan
Platycladus orientalis (L.) Franco	China and Japan
Plumeria alba L.	West Indies
Portulaca grandiflora Hook.	South America
Syzygium aromaticum (L.) Merr. & L.M.Perry	Maluku
Tagetes erecta L.	Africa/Mexico
Tridax procumbens L.	South America
Vicia lens (L.) Coss. & Germ.	Western temperate Asia
Zea mays L.	Central America

Biodiversity patterns

Another important observation was the use of roots of *Tinospora cordifolia*, twigs of *Euphorbia thymifolia,* and leaves of *Malvastrum coromandelianum* and *Butea monosperma* for making eco-friendly *Rakhi*. This indicates a wonderful exposition of human creativity using wild plants growing in their vicinity, highlighting the resourcefulness and ecological awareness of participants. The *Rakhi* made by code No. 09 utilized a combination of vegetables and pulses (two each). She used fruit slices of *Momordica dioica* and *A. esculentus*, which were really unique among the participants, and all the visitors were amused to see her imagination of making a *Rakhi* from these fruits and appreciated her innovative thinking beyond the conventional floral *Rakhi* models. The participant exhibited an exceptional ability to reimagine everyday plants in a fresh aesthetic and symbolic context, which is key to ethnobotanical creativity. It is important to mention here that *M. dioica* is a valuable Non-Timber Forest Product in Udaipur, which is usually sold at INR 250-300/kg during the rainy season. The use of leaves from the sacred plant, *Phyllanthus emblica*, as well as the leaf powder of *Camellia sinensis* for making *Rakhi* was another unique contribution by code No. 02 and 18, respectively. Overall, this reflects the flexibility of cultural practices integrating new and local plant resources, as well as promoting the biological awareness of invasive, wild, and edible plants. In this context, the eco-friendly *Rakhi* has become not only a craft but also a symbol of adaptive cultural resilience and sustainable innovation among youth.

Analysis of RFC values

RFC is a crucial quantitative tool to strengthen statistical integrity in ethnobotanical studies. It helps to find out the importance of a plant species as reported by informants in a study area. It measures the cultural significance of a species, that how widely known/valuable a plant is in a community, and higher RFC values suggest strong cultural relevance. The RFC values observed in this study ranged from 0.04 to 0.35, which were grouped as Low (0.01-0.10), Moderate (0.11-0.20), and High (0.21-0.40). Figure 5 depicts that the maximum plants had low RFC values (n=39), 6 plants had moderate, and 8 plants had high RFC values. The highest RFC value (0.35) was of *V. radiata* (n=8), followed by *O. sativa* and *Rosa* spp. (RFC=0.30 each), which 7 participants used, and *Piper nigrum* (RFC=0.26), which 6 participants used to make *Rakhi* (Table 2).

The reason behind the higher RFC value of Pulse crops, such as Mung Bean (*V. radiata*), Urd Bean (*Vigna mungo*), Gram (*C. arietinum*) and Lentil (*V. lens*); Cereals such as Rice (*O. sativa*); Spices such as Black Pepper (*P. nigrum*), Green Cardamom (*Elettaria cardamomum*) and Clove (*S. aromaticum*), and Dry fruits such as Pistachio (*P. vera*), could be due to their easy availability and access at the

participant's own homes. Rice was also reported to have the highest cultural significance index among 51 ritual plants used by the Aceh Tribe in Peureulak Sub-district, East Aceh, Indonesia, indicating its high importance and irreplaceable attribute for performing rituals (Sutrisno et al. 2020). Besides, the high RFC values of Rose (*Rosa* spp.) and Jasmine (*Jasminum* spp.) show their wide acceptance as beautiful fragrant flowers, as well as easy availability of these plants in surrounding areas, because, as ornamental plant species, these plants are frequently grown in most gardens and parks. Jasmine and Rose were also found to be the most favored plants for wearing in hair by young students and faculty members of a Women's College in Tamil Nadu, India (Ganga et al. 2025). However, higher RFC values also highlight the key species having cultural dependency and the need arising for their sustainable harvesting or initiating conservation programs (Chinnasamy et al. 2025; Krstin et al. 2024). An ethnobotanical plant inventory utilized by mountainous rural people of North West Portugal revealed that out of 98, 12 plants were used for performing various rituals, and the plant *Ruta graveolens* had the highest RFC value (Sá et al. 2024).

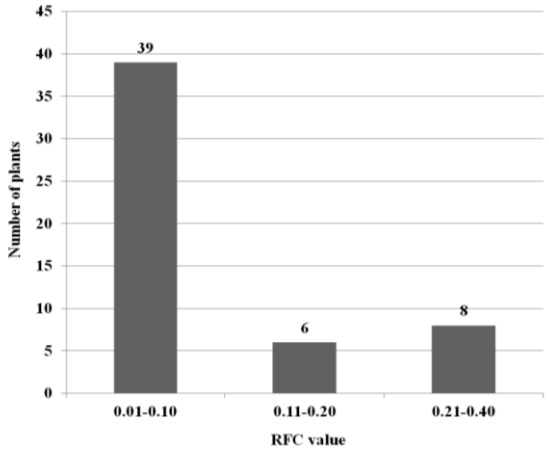

Figure 5. Number of plants grouped in three categories of RFC values

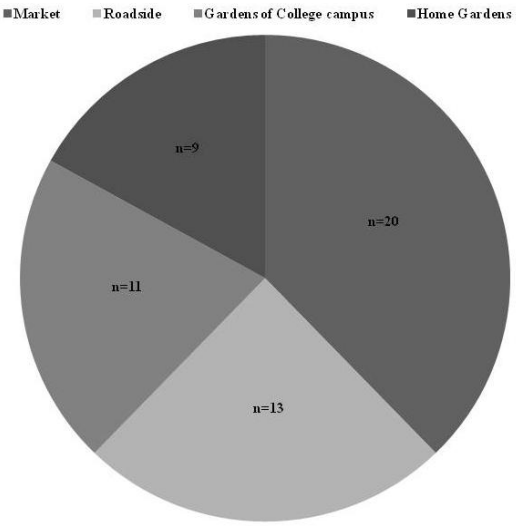

Figure 6. Percentage of plants procured from different areas (n = number of plants)

Cultural innovation and youth engagement

This ethnobotanical study is a first of its kind, and the creativity reflected in this competition revealed that there is enormous potential in the human mind, which can use its surrounding resources to fulfill all its needs. As living in urban spaces limits access to wild species, people start adapting to whatever is easily available to them. Moreover, habitat loss and overharvesting also jeopardize the accessibility of wild plant species. Steadily, a new foundation is laid between plants and man to build up a resilient need-based relationship. To illustrate, participants used 40 cultivated plants as these were frequently available in their surrounding areas, and only 13 wild plants to make *Rakhi* (Table 2). It is important to mention here that out of 13 wild plants, 7 species namely, *C. dactylon, E. thymifolia, L. camara, M. coromandelianum, P. hysterophorus, P. dactylifera* and *T. procumbens* were non-native to India but due to their rapid naturalization in the country, they are now growing in wild. Interestingly, integration of 40 cultivated plants into cultural rituals reflects their widespread acceptance among local traditions and belief systems.

Moreover, in present study, another important observation was that 38% plants were procured from markets, 24% from roadsides, 21% from gardens of the college campus and 17% from home gardens (Figure 6). The plants collected from markets include mostly lentils, vegetables, spices, and nuts. In contrast, most of the ornamental and fragrant plants were collected from gardens located at the college and at the homes of participants. This further indicates more use of plants growing in urban settings, as 38% of the plants were collected from gardens and markets, whereas collection of only 13 plants were done from roadside areas. Only 6 participants utilized the plants growing on the College campus and the nearby area in Madhuban (Table 1). This reflects the students' knowledge, perception, and attitudes toward plant biodiversity on campus and highlights the importance of botanical richness in educational settings for promoting sustainability and ecological consciousness. This also exhibits the adaptability of the human brain to satisfy the demands in every situation. However, a recent study on floral diversity and its role in environmental awareness conducted through an online questionnaire among faculty members and students of V.V.Vanniaperumal College for Women, Virudhunagar, Tamil Nadu has shown a lack of awareness about the ecological, medicinal, and environmental role of flowers and recommends integrating floral knowledge into education to strengthen ecological literacy (Ganga et al. 2025).

A recent global bibliometric analysis by Marsandi et al. (2025) has revealed that education systems can play a vital role in preserving cultural heritage by training the young generation to respect and uphold traditional values. Furthermore, integrating local wisdom into curricula enables students to create community-based solutions for local issues. It requires an interdisciplinary approach that emphasizes ecological, educational, and socio-economic factors, aligning scientific learning with cultural values, environmental consciousness, and community well-being.

Therefore, there is a need to conduct more such eco-consciousness-promoting events incorporating traditional wisdom along with a sustainability outlook among the young generation. This will raise environmental awareness but will showcase various levels of human creativity using different plants in their surroundings. These programs could not only foster appreciation for biodiversity but could also connect cultural heritage with modern ecological responsibility. For example, these initiatives could be useful for fulfillment of UN Sustainable Development Goals (SDGs) such as SDG 4 - providing quality education by engaging students in real world sustainability practices; SDG-12 by encouraging eco-friendly, biodegradable material for making *Rakhi* to become responsible consumer and producer and SDG-15 by raising awareness about plant diversity and their conservation needs, thereby, helping in protection of life on land. Besides, it also aligns with the National Education Policy 2020, which emphasizes holistic, multidisciplinary education imparting skill-based learning and availing local knowledge systems. This art-integrated competition is helpful for experiential learning by blending Ethnobotany, Environmental Sciences, and traditional art, as well as promoting ethical engagement with natural resources through value-based education. The plant-based innovations offer pathways for addressing global challenges and foster economic resilience, environmental preservation, and social equity (Krzywonos and Piwowar-Sulej 2022). Therefore, encouraging similar initiatives across institutions can deepen students' understanding of the interconnection between culture, environment, and responsible citizenship.

In the current era, urbanization is rapidly increasing and bringing changes to traditional lifestyles and the use patterns of urban plant diversity. Though it has been shown to affect the traditional medicinal knowledge and biodiversity, it also provides opportunities for innovation and cultural extension (Arjona-García et al. 2021). Interestingly, the use of plants growing in urban settings, for example, *Bougainvillea spectabilis*, *C. indicum, Cosmos sulphureus, Ixora coccinea, P. orientalis, T. erecta,* etc., was also observed in the present study, reflecting the importance of urban biodiversity not only for aesthetic purposes but also for cultural utility. This also provides rich insights into how plants are intricately connected with people, whether growing in rural or urban settings, highlighting the dynamic relationship between people and plants in everyday life. *Tagetes erecta* has also shown a high cultural importance index as being used for various rituals and socio-religious activities among 95 local vegetables sold at a community market in Kantarawichai District, Thailand (Saensouk et al. 2025).

The urban green spaces act as living repositories of plant-based materials that are easily accessible, visually attractive, and seasonally synchronized with the *Rakhi* festival, encouraging their use in traditional crafts. On the other hand, home gardens in urban areas are another valuable land area filled with urban plant diversity vis-à-vis traditional knowledge and cultural values. In the present study, nine plants were collected from home gardens and 11 from College campus gardens (Figure 6). As cities are growing rapidly, recognizing this role of urban flora can enhance both community engagement and sustainability education, as urban biodiversity can contribute to cultural resilience and creativity. The urban ecological habitats lie at the intersection of biodiversity, cultural heritage, and sustainability, and therefore, are carefully negotiated. Further, these findings emphasize the need for expansion of the conventional Ethnobotany regime towards Urban Ethnobotany, which is the need of the hour (de Santana et al. 2024; Hou et al. 2024).

Conservation implications

Ethnobotanical studies also indicate the gap between traditional knowledge and formal conservation science. These studies help to identify the plant species that are culturally valuable but are vulnerable and need conservation prioritization (Pei et al. 2020). In the present study, it was observed that, as per the IUCN Red List, *P. orientalis* and *P. vera* belong to the Near Threatened category (IUCN 2025), indicating that if the current trends continue for their exploitation, they are at great risk of becoming endangered in the near future. Besides, a decreasing population trend is mentioned for *P. emblica* (IUCN 2025), whose fruits are well-known for their nutraceutical properties and cultivated widely in South Rajasthan (Avinash et al. 2024). This raises concerns about the sustainable use of plant species and the need to promote conservation strategies to prevent extinction. Additionally, implementing sustainable harvesting guidelines based on ecological assessments is essential. These guidelines should specify acceptable extraction limits, ensure natural regeneration, and support habitat conservation. Rotation harvesting and controlled collection periods are vital to reduce pressure on wild populations. Habitat restoration is also a crucial part of any conservation plan, and traditional knowledge can serve as a valuable guide to saving particular plant species (Haq et al. 2023). Especially, *in-situ* conservation by encouraging the cultivation and use of locally available plant species could be adopted. As the demand for plant-based *Rakhi* increases, community members may be incentivized to grow culturally important species in home gardens or community spaces, thereby restoring degraded flora and supporting local biodiversity. However, there is a risk of overharvesting if the popularity of plant-based *Rakhi* outpaces sustainable supply. Therefore, coupling such initiatives with environmental education on sustainable harvesting and cultivation techniques, responsible use, and conservation planning is crucial. In this way, cultural practices could be used to ensure climate resilience.

Ethnobotany and sustainable bio-economy: A transformative link

Ethnobotany is an emerging and dynamic branch of science that can aid in the development of a sustainable Bioeconomy. In this regard, the recent introduction of the concept, 'One Student, One Product', is a thought-provoking opportunity that merges tradition, sustainability, and entrepreneurship (Saklani 2024). The Ethnobotany-oriented entrepreneurship can not only boost the economic

condition of the local community but can also be helpful to project that particular region on the global tourist canvas. In this context, the recent initiative of biodegradable floral *Rakhi* prepared from dehydrated plant material by CSIR-National Botanical Research Institute, Lucknow, Uttar Pradesh, is worth mentioning. If the participants of the present study can prepare any such eco-friendly *Rakhi* on a large scale and proper marketing of the product is carried out, then this venture could certainly be a valuable source for generating income during the *Rakhi* festival as a micro-seasonal economic benefit. Digital platforms could be used to promote their eco-ethnic *Rakhi*. Financial and logistic assistance or industrial support, thus required for upscaling of such grassroots innovations, could be availed through various schemes of the Government of India and entrepreneurial development programs. Later, hands-on crafting workshops with ethnobotanical relevance could be organized for awareness and skill development among youth. In fact, such competitions, if scaled up, could open doors for farmers and local artisans to supply eco-friendly raw materials to foster a green economy. This insight highlights the applied dimension of Ethnobotany, where traditional plant knowledge meets innovation, especially in the context of environmentally responsible economic models. This aligns with broader goals of sustainable development, cultural preservation, and rural empowerment.

In conclusion, ethnobotanical investigations at festivals of a particular area or a community could provide immense botanical knowledge. That knowledge could be helpful for biodiversity conservation, socio-economic upliftment, ethnic/gastronomic tourism, taxonomic or cultural utility purposes. The use of 53 plants for making eco-friendly *Rakhi* in the present study indicates how the need-based man-plant relationships could be useful to preserve and foster culture-based man-plant relationships, which in turn could strengthen biodiversity conservation by encouraging community engagement in preserving plant diversity. This showcase how cultural traditions can align with environmental education and how a traditional festival, '*Rakhi*', could be celebrated in an eco-friendly manner without compromising the cultural significance. If the innovative *Rakhi* created in this study are scaled with proper training and marketing, they could form the basis of a circular, green business model that not only supports local economies but also positions the region as a hub of eco-cultural innovation. Though the study has its own limitations, it offers a replicable model for using festivals as platforms for raising ecological awareness, reviving local knowledge, and engaging communities in sustainable living practices. However, the urgency and significance of ongoing research cannot be overstated, as it is essential for understanding man-plant relationships and their impact on biodiversity conservation. Besides, a shift towards the use of cultivated and accessible plants is observed in the study, indicating the influence of urbanization, education, and awareness. Based on the results obtained in the study, it is recommended that such kind of investigations should be carried out from time to time to know about both need-based and culture-based man-plant relationships in detail, as well as the impact of surrounding plant diversity in building that relationship.

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