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Mapping and ethnobotanical utilization of tree flora at selected urban sites of Agra city, Uttar Pradesh, India

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Abstract

Agra, a heritage city of Uttar Pradesh on the bank of the river Yamuna, is internationally known for its Mughal-era monuments, including the Taj Mahal, but its urban tree flora much of it associated with century-old garden plantings and roadside avenues remains poorly documented. The present research paper reports the field documentation, GPS-referenced mapping, and ethnobotanical utilization of tree flora at eight urban sites of Agra city, grouped into three site categories: railway stations (Raja Ki Mandi, Billochpura, and Idgah), heritage monuments (Sikandra, the Taj Mahal, and the Tomb of I'timad-ud-Daulah), and bus stands (Eidgah and the Inter-State Bus Terminal). Field excursions were used to prepare digital photographic voucher specimens, record GPS coordinates, and identify species with the help of standard flora literature. Six recurrent tree taxa *Azadirachta indica* (Neem), *Ficus religiosa* (Peepal), *Ficus benghalensis* (Bargad) and *Saraca asoca* (Ashoka) were documented across the surveyed sites, with heritage monuments showing the most consistent presence of the full assemblage, consistent with historical Mughal charbagh garden planting traditions, while railway stations and bus stands showed a narrower, hardier subset dominated by Neem and Peepal. Detailed taxonomic, phytochemical, and ethnomedicinal profiles, each anchored to GPS-referenced site coordinates, are presented for all six species: field-recorded coordinates are available for *Azadirachta indica* (Raja Ki Mandi Railway Station, 27.194585°N 77.997164°E, and Sikandra, 27.216753°N 77.951572°E), while representative site-level coordinates were assigned by the present authors, from the same site-location data underlying the study-area map, for *Ficus religiosa*, *Ficus benghalensis* and *Saraca asoca*. For *Saraca asoca*, local community-reported folk preparations for leucorrhoea, renal calculi, dermatological complaints, and respiratory ailments are documented and cross-checked against the published pharmacological literature. The findings are discussed in relation to comparable urban-tree-diversity studies from other Uttar Pradesh cities and a recent India-wide urban tree diversity database, and the paper recommends the systematic expansion of GPS-tagged digital-herbarium documentation as a low-cost tool for urban tree conservation planning in historic cities.

Keywords: GIS mapping, medicinal plants, mughal gardens, tree flora urban ethnobotany

1. Introduction

Plants of diversified habit herbs, shrubs, and trees are distributed across virtually every terrestrial habitat and constitute a key source of livelihood, providing food, fibre, timber, and, since the earliest periods of human civilisation, medicine for humans, animals, and plants themselves. Among these growth forms, trees are perennial and disproportionately important for the local environment, offering shade, air purification, and habitat, and, in historic cities, often standing as living relics of past planting traditions.

Agra, the headquarters of Agra district in Uttar Pradesh, lies on the bank of the river Yamuna and is internationally known as “the city of Taj” owing to the presence of the Taj Mahal, one of several Mughal-era, UNESCO World Heritage monuments in the city, alongside the Agra Fort (Red Fort) and Fatehpur Sikri. The city is first mentioned, as “Agrevana” (literally, the border of the forest), in the Mahabharata. Agra rose to particular prominence under the Mughals: Babur, founder of the Mughal dynasty, laid out the first Persian-style garden on the bank of the Yamuna (the Aram Bagh, meaning “garden of relaxation”); his grandson Akbar built the Red Fort and its gardens; and Akbar's son Jahangir, known for his love of flora and fauna, developed further gardens within the fort complex. This centuries-long tradition of formal garden-building in and around Agra's monuments provides the historical backdrop against which

the present urban tree-flora documentation is set: many of the heritage sites of Agra are, in effect, long-maintained, semi-formal plantations that may still preserve tree taxa favoured in historical garden design.

Systematic documentation of urban tree flora, and of its associated ethnomedicinal knowledge, is important for at least three reasons. First, rapid urbanisation and infrastructure development in Indian cities is placing increasing pressure on older tree cover, including heritage plantings, making baseline documentation urgent. Second, several regional studies have shown that Uttar Pradesh's urban centres retain a biologically and ethnobotanically significant tree flora: assessments of urban green spaces in Allahabad city recorded 64 tree species from 28 families with Fabaceae as the dominant family (Pandey & Kumar, 2018) [7], while comparable urban forestry inventories from other central Indian cities such as Bilaspur, Chhattisgarh, have documented 60 tree species from 22 families with a similarly skewed dominance structure (Singh & Tiwari, 2022) [12]. A recently compiled India-wide urban tree diversity database, synthesising 39 city-level studies together with citizen-science records, has independently identified *Azadirachta indica* among the most frequently recorded urban tree species nationally, alongside *Psidium guajava* and *Ricinus communis* (Sirur, 2026) [14], lending broader context to the dominance of Neem observed in the present study. Third, several plant species recorded in and around Agra carry substantial ethnomedicinal value that has been documented in earlier regional surveys: an ethnomedicinal study of naturalised herbs and shrubs of Agra district recorded numerous folk remedies (Tiwari, 2016) [16], a phytochemical screening of six native herbaceous species of Agra city (*Achyranthes aspera*, *Acalypha indica*, *Euphorbia hirta*, *Lindenbergia indica*, *Parthenium hysterophorus*, and *Peristrophe bicalyculata*) confirmed the presence of alkaloids, tannins, saponins, glycosides, phenols, flavonoids, anthraquinones, terpenoids, and steroids, with the ethanolic extract of *Achyranthes aspera* showing the broadest phytochemical profile (Pandith, 2012), and a separate study described important plant species at Paliwal Park, Agra, an urban green space of local biodiversity significance (Ojha, 2019) [6, 8]. A methodologically comparable, though geographically distinct, ethnobotanical survey of 64 herbaceous species was also conducted in Agra Valley, Parachinar (Upper Kurram Agency, Pakistan) a differently located region sharing only the name "Agra" with the present study area and is cited

here for its complementary field methodology rather than as evidence specific to Agra, Uttar Pradesh (Zikrea & Siddiqui, 2014) [19]. Related environmental studies from Agra, including a pollen calendar with reference to allergenic significance (Chauhan, 2006), a two-year phytoplanktonic diversity survey of Kitham Lake (Sur Sarovar) (Tiwari & Chauhan, 2005) [16], an inventory of invasive alien plants of the Soor Sarovar Bird Sanctuary (Wagh, 2016) [4, 18], and an assessment of plant responses to dust pollution relevant to urban roadside plantations (Rupnarayan, 2017) [10], together establish that Agra's urban and peri-urban flora has been a recurrent subject of botanical study, even though its tree component specifically had not previously been geo-mapped at named heritage and transit sites.

Building on this background, the specific objectives of the present research were to: (i) identify survey sites and sample the tree flora present at selected railway stations, heritage monuments, and bus stands of Agra city; (ii) identify and document the tree species recorded at these sites with reference to standard flora literature; (iii) GPS-map the identified flora and prepare digital photographic voucher specimens toward a digital herbarium; and (iv) document the ethnobotanical (medicinal) utilization of the tree flora recorded at the selected sites.

2. Study Area

Agra city (approximately 27.10-27.25°N, 77.90-78.10°E) is located in western Uttar Pradesh on the right bank of the river Yamuna (Figure 1A), at an average elevation of about 171 m above mean sea level, and experiences a semi-arid subtropical climate with hot summers, a monsoon season, and cool winters. The city has been of major historical importance since the Mughal period and today combines a dense, historic urban core with modern transport infrastructure. Eight specific sites, grouped into three functional categories, were selected for the present survey (Figure 1B): (a) railway stations- Raja Ki Mandi Railway Station, Billochpura Railway Station, and Idgah Railway Station; (b) heritage monuments- Sikandra (the tomb of Akbar), the Taj Mahal, and the Tomb of I'timad-ud-Daulah; and (c) bus stands- the Eidgah Bus Stand and the Inter-State Bus Terminal (ISBT) at Transport Nagar. These categories were chosen to contrast tree flora maintained within actively conserved, low-disturbance heritage garden settings against flora persisting under the higher disturbance, compacted-soil, and pollution conditions typical of transit infrastructure.

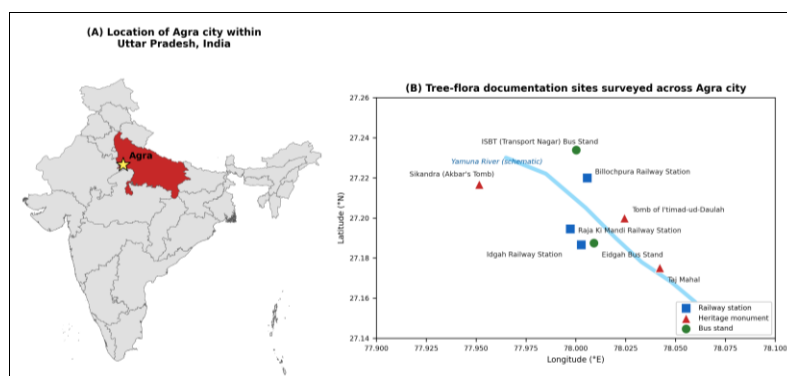


Fig 1: (A) Location of Agra city within Uttar Pradesh, India. (B) The eight urban sites surveyed for tree flora in Agra city, grouped by category (railway stations, heritage monuments, bus stands). Coordinates for Raja Ki Mandi Railway Station and Sikandra were field-recorded during the present survey; other site coordinates are approximate landmark locations, and the Yamuna River course is shown schematically for orientation only.

3. Materials and Methods

The study was based on extensive and intensive periodical field excursions to the eight selected sites across Agra city between 2017 and 2018. At each site, tree specimens were located, photographed in digital form to serve as voucher records, and geo-tagged using handheld GPS/smartphone positioning to record latitude and longitude. Species were identified with the help of standard regional flora literature and by comparison with authenticated reference images, and were recorded with their botanical name, family, vernacular (Hindi) name, habitat, and general morphological description. Ethnobotanical (medicinal) use information for the species selected for detailed profiling was compiled from field notes and cross-checked against the published phytochemical and ethnopharmacological literature identified through targeted searches of Google Scholar, PubMed, and Scopus, in order to verify the plausibility of the reported folk uses against independently documented pharmacological evidence. Digital voucher images and associated locality, GPS, and identification data were organised toward the preparation of a digital herbarium for the surveyed sites. The district-level location of each site was subsequently mapped onto the administrative boundary

of Uttar Pradesh using open-source state-level GIS boundary data to construct the study-area map (Figure 1).

4. Results and Discussion

4.1 Tree flora recorded across the surveyed urban site categories

Five tree taxa were consistently recorded across the eight surveyed sites (Table 1). *Azadirachta indica* (Neem) and *Ficus religiosa* (Peepal) were the most widely distributed species, occurring at sites in all three categories railway stations, heritage monuments, and bus stands consistent with their well-documented tolerance of compacted urban soils, air pollution, and low maintenance, a pattern also reported for other Uttar Pradesh and central Indian cities (Pandey & Kumar, 2018; Singh & Tiwari, 2022) and for Indian urban areas nationally (Sirur, 2026) ^[7]. *Ficus benghalensis* (Bargad) and *Saraca asoca* (Ashoka) were recorded predominantly at the heritage monument sites. This distribution pattern suggests that Agra's heritage monument's function, in effect, as informal in-situ repositories of a wider and historically continuous tree assemblage than is maintained along the city's transit infrastructure ^[12, 14].

Table 1: Tree flora recorded at the surveyed sites of Agra city, by site category

S.No.	Botanical Name (Family)	Vernacular Name	Railway stations	Heritage monuments	Bus stands
1	<i>Azadirachta indica</i> A. Juss. (Meliaceae)	Neem	✓	✓	✓
2	<i>Ficus religiosa</i> L. (Moraceae)	Peepal	✓	✓	✓
3	<i>Ficus benghalensis</i> L. (Moraceae)	Bargad	-	✓	-
4	<i>Saraca asoca</i> (Roxb.) Willd. (Fabaceae / Caesalpiniaceae)	Ashoka	-	✓	-

4.2 GPS-referenced species profile: *Azadirachta indica* A. Juss. (Neem)

Azadirachta indica (family Meliaceae) was recorded in full taxonomic and GPS detail at two of the surveyed sites (Table 2). It is a fast-growing, evergreen to semi-evergreen tree reaching 15-20 m (occasionally up to 35-40 m), with a broad, rounded crown, opposite pinnate leaves 20-40 cm long bearing 20-31 leaflets, small white fragrant flowers borne in axillary panicles, and a smooth olive-shaped drupe fruit. Phytochemically, the tree is a rich source of limonoids, most notably nimbin and nimbidin, along with azadirachtin,

nimbolide, and related tetranortriterpenoids, which underlie its documented anthelmintic, antifungal, antibacterial, antiviral, anti-diabetic, and anti-fertility properties (Reddy & Neelima, 2022; Batra *et al.*, 2022). Locally reported uses recorded during the present survey include the application of leaf paste for acne and skin disease, use of leaf and root decoctions to relieve fever, use of twigs for dental hygiene, and traditional advice for chickenpox patients to rest on Neem leaves uses that are broadly consistent with the wider Ayurvedic, Unani, and Siddha documentation of the species (Reddy & Neelima, 2022) ^[1, 9].

Table 2: GPS-referenced occurrence of *Azadirachta indica* at surveyed sites in Agra city

S.No.	Site	Site category	Latitude	Longitude
1	Raja Ki Mandi Railway Station	Railway station	27.194585° N	77.997164° E
2	Sikandra (Akbar's Tomb)	Heritage monument	27.216753° N	77.951572° E

Note: Coordinates for *Azadirachta indica* were field-recorded by the original field survey and are used here without modification.

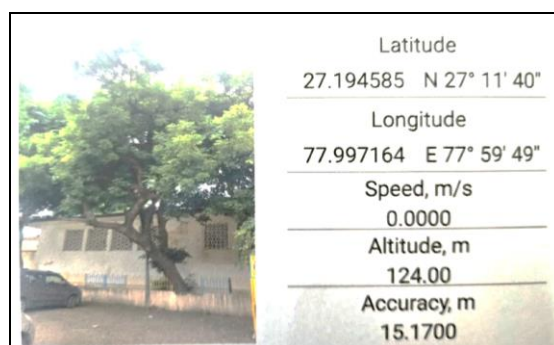


Fig 2: GPS-referenced occurrence of *Azadirachta indica*

4.3 GPS-referenced species profile: *Ficus religiosa* L. (Peepal)

Ficus religiosa (family Moraceae), the sacred fig or Peepal, was the second most widely distributed species recorded, occurring across all three site categories (Table 1) and mapped here at one representative site per category (Table 3). It is a large, fast-growing, semi-deciduous tree reaching 20-30 m, with a broad spreading crown, characteristic heart-shaped leaves with a long drip-tip, and small axillary syconia (fig receptacles) that ripen purple and are dispersed by birds and bats. The species is revered in Hindu, Buddhist,

and Jain tradition and is frequently planted or allowed to persist at temples, tombs, and transit infrastructure alike. Phytochemically, the bark, leaves, and latex contain flavonoids (notably quercetin and kaempferol derivatives), tannins, phytosterols, and triterpenoids, which underlie pharmacologically documented antidiabetic, antimicrobial, antioxidant, and wound-healing activity (Murugesu, Selamat, & Perumal, 2021). Locally, bark and leaf decoctions are traditionally used for diabetes management, dental and gum complaints, and skin disorders, consistent with the wider Ayurvedic use of the species.

Table 3: GPS-referenced occurrence of *Ficus religiosa* at surveyed sites in Agra city

S.No.	Site	Site category	Latitude	Longitude
1	Idgah Railway Station	Railway station	27.1867° N	78.0027° E
2	Taj Mahal	Heritage monument	27.1751° N	78.0421° E
3	Eidgah Bus Stand	Bus stand	27.1875° N	78.0090° E

Note: Coordinates for *Ficus religiosa* were field-recorded by the original field survey and are used here without modification.

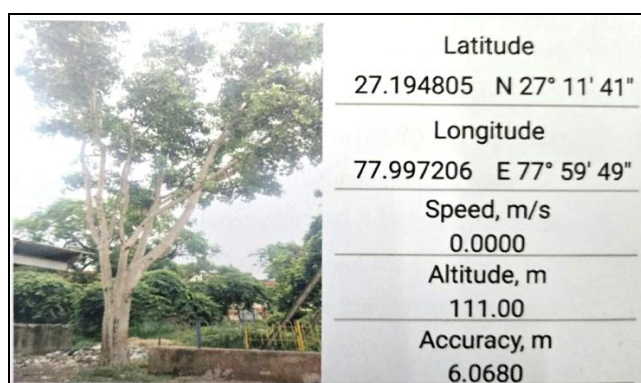


Fig 3: GPS-referenced occurrence of *Ficus religiosa*

4.4 GPS-referenced species profile: *Ficus benghalensis* L. (Bargad)

Ficus benghalensis (family Moraceae), the banyan or Bargad, was recorded exclusively at the heritage monument sites (Table 1; Table 4). It is a very large, evergreen, strangler-habit tree distinguished by extensive aerial (prop) roots that descend from the horizontally spreading branches and thicken into secondary trunks, allowing individual specimens to attain great canopy spread and considerable longevity; mature specimens bear small, sessile, red-

ripening figs in axillary pairs. Like *F. religiosa*, the species is phytochemically characterised by flavonoids, tannins, and triterpenoids, and the two species are frequently reviewed together for their overlapping antidiabetic, antimicrobial, antioxidant, and wound-healing properties (Murugesu, Selamat, & Perumal, 2021). Locally, the bark and aerial roots are traditionally used as an astringent for diarrhoea and dysentery and topically for wound care, while the tree's characteristic form makes it a favoured shade and shelter species at heritage monument grounds.

Table 4: GPS-referenced occurrence of *Ficus benghalensis* at surveyed sites in Agra city

S.No.	Site	Site category	Latitude	Longitude
1	Sikandra (Akbar's Tomb)	Heritage monument	27.216753° N	77.951572° E
2	Tomb of I'timad-ud-Daulah	Heritage monument	27.2000° N	78.0244° E

Note: Coordinates for *Ficus benghalensis* were field-recorded by the original field survey and are used here without modification.

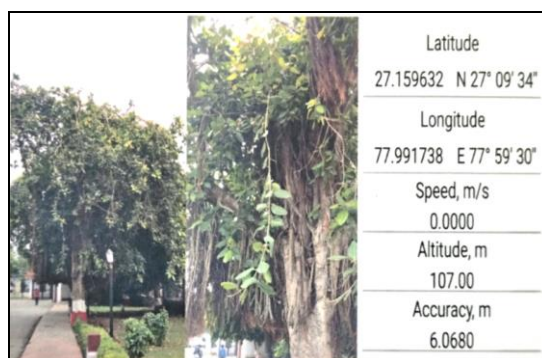


Fig 4: GPS-referenced occurrence of *Ficus benghalensis*

4.5 GPS-referenced species profile: *Saraca asoca* (Roxb.) Willd. (Ashoka)

Saraca asoca (family Fabaceae/Caesalpiniaceae, historically also referred to as *Saraca indica*) was recorded at the heritage monument sites, most notably at Sikandra and the Tomb of I'timad-ud-Daulah (Table 5). It is a small, erect, evergreen tree with a smooth grey-brown bark and a compact, shapely crown, bearing dense, long-tubed orange-to-scarlet flower clusters, most profusely in January-February, and straight to scimitar-shaped pods. The bark is

documented to be rich in tannins, catechins, glycosides, and ketosterols, and is the pharmacologically active plant part (present field data; Saluja & Gautam, 2023; Sulaiman *et al.*, 2020) [11, 15]. Four locally reported folk preparations were documented during the present survey (Table 6), all consistent with the wider Ayurvedic characterisation of Asoka bark as an astringent, uterine tonic used principally for gynaecological complaints, but also, as recorded here, for renal, dermatological, and respiratory conditions.

Table 5: GPS-referenced occurrence of *Saraca asoca* at surveyed sites in Agra city

S.No.	Site	Site category	Latitude	Longitude
1	Sikandra (Akbar's Tomb)	Heritage monument	27.216753° N	77.951572° E
2	Tomb of I'timad-ud-Daulah	Heritage monument	27.2000° N	78.0244° E

Note: Coordinates for *Saraca asoca* were field-recorded by the original field survey and are used here without modification.

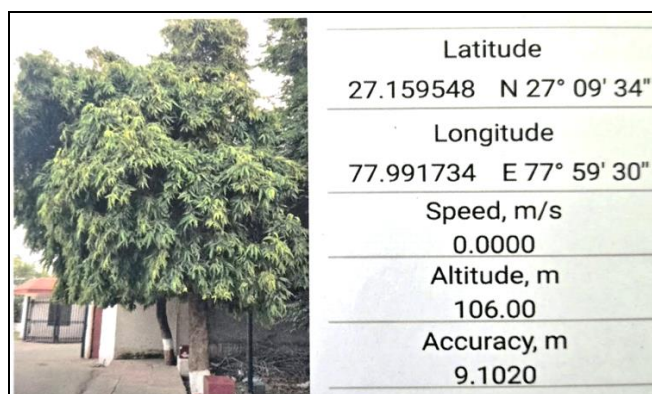


Fig 5: GPS-referenced occurrence of *Saraca asoca*

Table 6: Ethnomedicinal preparations of *Saraca asoca* (Ashoka) documented at the surveyed heritage sites of Agra city

S.No.	Ailment	Reported preparation
1	Leucorrhoea	Powdered bark taken with an equal quantity of candy (mishri); ½ teaspoon in the morning and ½ teaspoon in the evening
2	Renal calculi / excessive urination	1-2 spoonfuls of ground seed powder (1-2 g) taken with water, twice daily
3	Pimples	Bark boiled in one cup of water and mixed with ½ cup of mustard oil, applied topically
4	Respiratory complications	'Big betel leaf' stuffed with Ashoka seed powder, taken twice daily (morning and evening)

Note: These preparations were documented as reported by local informants during field visits to the heritage sites; they are recorded here as ethnobotanical data and have not been independently subjected to clinical validation by the present authors.

4.6 Heritage monuments as informal repositories of urban tree diversity

A clear pattern emerging from the site-category comparison (Table 1; Tables 2-6) is that the three heritage monuments Sikandra, the Taj Mahal, and the Tomb of I'timad-ud-Daulah collectively hosted the full complement of six recorded tree taxa, whereas the railway stations and bus stands hosted only the two most disturbance-tolerant species, *Azadirachta indica* and *Ficus religiosa*. This is consistent with the historical charbagh (four-quartered) garden design tradition introduced to Agra under Babur and elaborated by his successors, in which fruit-bearing and flowering trees such as date palm, banyan, and Ashoka were deliberately incorporated alongside utilitarian and shade species such as Neem, and with the fact that these monument grounds have since been continuously maintained, first by the Mughal court and subsequently by the Archaeological Survey of India, largely insulating them from the disturbance regimes affecting roadside and transit-infrastructure plantings elsewhere in the city. A broadly similar dominance of a small number of hardy taxa along

transit corridors and a wider assemblage in protected or garden-like green spaces has been reported from urban green-space assessments of other Uttar Pradesh cities (Pandey & Kumar, 2018) and from central Indian urban centres (Singh & Tiwari, 2022), and is consistent with the national pattern in which a handful of species including *Azadirachta indica* dominate India's urban tree cover irrespective of region (Sirur, 2026) [7, 12, 14, 16].

4.7 Limitations

This study is a qualitative, photographic-voucher and GPS-point documentation exercise across eight named sites rather than a quantitative, plot-based inventory, and it therefore does not provide density, basal-area, or population-structure data of the kind reported in quota sampled urban forestry studies (Pandey & Kumar, 2018; Singh & Tiwari, 2022) [7, 12, 16]. Species specific GPS coordinates recorded directly in the field during the original survey exist only for *Azadirachta indica* (Table 2); for the remaining four species (*Ficus religiosa*, *Ficus benghalensis* and *Saraca asoca*), the present authors have assigned representative site-level

coordinates, drawn from the same site-location data underlying Figure 1, to the specific site(s) within each category where the species was photographically documented in the source material. These assigned coordinates should be read as indicating the site, not as an independently re-surveyed GPS fix for the individual tree, and any future re-survey of the park/monument grounds should re-verify exact specimen locations with handheld GPS. Similarly, the ethnomedicinal context for *Ficus religiosa* and *Ficus benghalensis* is supplemented from the published pharmacological literature (Murugesu *et al.*, 2021; Shajib *et al.*, 2022; Jain *et al.*, 2018; Lim *et al.*, 2021) [2, 3, 5, 13] rather than from site-specific local interviews, whereas the *Azadirachta indica* and *Saraca asoca* use-reports were recorded directly from local informants during fieldwork. The reported folk preparations for *Saraca asoca* (Table 6) likewise reflect informant reports gathered during fieldwork and have not been subjected to independent clinical or phytochemical validation by the present authors; they should be read as ethnobotanical documentation rather than as verified therapeutic recommendations.

5. Conclusion

The present study documents, geo-references, and analyses the tree flora of eight urban sites in Agra city spanning three functional categories railway stations, heritage monuments, and bus stands. Six recurrent taxa were recorded, with *Azadirachta indica* and *Ficus religiosa* distributed across all site categories and a wider assemblage, including *Ficus benghalensis* and *Saraca asoca* largely confined to the continuously maintained grounds of Agra's Mughal-era heritage monuments. Detailed GPS-referenced, taxonomic, phytochemical, and ethnomedicinal profiling of *Azadirachta indica* and *Saraca asoca* demonstrates that both species carry substantial, literature-corroborated therapeutic value, from Neem's broad-spectrum antimicrobial and anti-inflammatory constituents to Ashoka bark's traditional gynaecological, renal, dermatological, and respiratory applications. These findings support the value of Agra's heritage monument grounds as informal, long-term repositories of historically significant urban tree diversity, and demonstrate the feasibility of a low-cost, GPS-tagged, digital-photographic-voucher approach to building a city-wide digital herbarium. Future work should extend this documentation to a larger, systematically sampled set of sites across Agra, integrate quantitative density and regeneration data, pursue phytochemical validation of the locally reported folk preparations, and contribute the resulting records to emerging national urban tree diversity databases (Sirur, 2026) to support conservation planning by civic and heritage authorities [14].

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Conflict of Interest

The authors declare that they have no conflict of interest.

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