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Auditing the Magahi paan (*Piper betle* L.) geographical indication: Ayurvedic claims, field observations and governance

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ABSTRACT: Geographical indications (GIs) increasingly market traditional plant products on the strength of origin and health, yet the evidence written into their specifications is seldom tested in the field. Taking an Ayurveda-biology perspective, we studied Magahi paan (*Piper betle* L.), the betel leaf of Bihar's Magadh region registered as GI No. 554. Primary data were collected in March 2025 through field visits across one of the four GI districts, comprising face-to-face interviews with 27 growers and direct, photo-documented observation of conservatory (*baroj*) construction and cultivation. These were combined with directed content analysis of ten official GI documents (2016–2026), a geospatial check of 52 published village coordinates, and evaluation of the 12 codified medicinal claims against classical Ayurvedic texts on *tāmbūla* and the biomedical literature. Field observation confirmed the labour-intensive practices the specification describes, with planting, staking and irrigation all done by hand. The producers' society holding the registration was formed only after it replaced the university applicant, and the medicinal claims entered at the examiner's request from two secondary sources. None had human clinical evidence; only the oral-hygiene uses matched classical Ayurveda, and the claim that the leaf stops nasal bleeding contradicts both the *Aṣṭaṅga Hṛdaya*, which contraindicates *tāmbūla* in bleeding disorders, and the antiplatelet action of hydroxychavicol. The essential-oil profile presented as Magahi paan came from one market sample bought outside the territory, and 5 of 52 coordinates fell outside their listed district. GI specifications for medicinal plants should combine field-verified practice, chemical criteria and Ayurvedic contraindications with evidence-graded health claims.

1. INTRODUCTION

Betel vine (*Piper betle* L., Piperaceae) is a perennial, dioecious climber grown for its leaf across South and Southeast Asia. In India the leaf is chewed by an estimated 15–20 million people, offered in ritual and traded over long distances, which has earned it the name of a neglected "green gold" (Guha, 2006). The leaf is chemically rich. Reviews list hydroxychavicol (allylpyrocatechol), chavibetol, chavicol, eugenol, acetyleugenol and β-caryophyllene among its main constituents and report antimicrobial, antioxidant, anti-inflammatory, gastroprotective, antidiabetic and antiproliferative activities, nearly all of them in

laboratory or animal models (Madhumita et al., 2020; Nayaka et al., 2021; Biswas et al., 2022; Singh et al., 2023). Hydroxychavicol has drawn particular interest as a candidate chemopreventive compound (Gundala and Aneja, 2014; Mohamad et al., 2023).

This promise sits beside a well-documented hazard. The leaf is mostly consumed as the wrapper of betel quid, which usually contains areca nut and often tobacco. The International Agency for Research on Cancer classifies betel quid with or without tobacco, and areca nut itself, as carcinogenic to humans (Group 1), while noting evidence that suggests a lack of carcinogenicity of betel leaf alone in experimental animals (IARC, 2004, 2012). Areca nut chewing carries a pooled adjusted relative risk of oral cancer of 7.9 (Warnakulasuriya and Chen, 2022) and quid use is the main cause of oral submucous fibrosis (Cirillo et al., 2022); in Bihar, 3.4% of adults used betel quid with tobacco in 2016–17 (MoHFW and TISS, 2017), against 21.4% of Indian adults using smokeless tobacco of any kind (MoHFW and TISS, 2018). Some authors argue that the leaf has been wrongly maligned by its association with the quid (Rai et al., 2011), while clinical reviews stress the harm of the quid as consumed (Sharan et al., 2012). Either way, health statements attached to an origin-certified leaf can be read as endorsing a practice that public health policy seeks to reduce.

Betel leaf also has a long place in Ayurveda. As *tāmbūla* it appears in the classical regimen for oral hygiene: the *Caraka Saṃhitā* advises keeping fresh betel leaves in the mouth, with other aromatics, for "cleanliness, relish and fragrance of breath" (*Caraka Saṃhita*, Sūtrasthāna 5.76–77; Shree Gulabkunverba Ayurvedic Society, 1949), and the *Suśruta Saṃhitā* already refers to areca-nut chewing (IARC, 2004). Ayurvedic pharmacology describes the leaf as light, dry and sharp, bitter in taste and hot in potency, a substance that pacifies *vāta* and aggravates *pitta* (Tiwari et al., 2025). The same tradition is explicit about when the leaf should not be used: the *Aṣṭaṅga Hṛdaya* declares *tāmbūla* unwholesome for people with wounds, bleeding disorders, dry and inflamed eyes, poisoning, fainting, intoxication or wasting (*Aṣṭaṅga Hṛdaya*, Sūtrasthāna 2.7; Srikantha Murthy, 1991). Ayurvedic biology, an emerging field that tests classical Ayurvedic knowledge with the methods of modern biology (Joshi et al., 2023), therefore offers a natural lens for any official text that attributes "traditional" medicinal virtues to betel leaf.

Geographical indications (GIs) identify goods originating in a territory where a given quality, reputation or other characteristic is essentially attributable to geographical origin (WTO, 1994). India gave effect to this obligation through the Geographical Indications of Goods (Registration and Protection) Act, 1999 and its Rules of 2002 (Government of India, 1999, 2002). By July 2024 the GI Registry in Chennai had registered 643 GIs, 605 of them Indian (Lok Sabha, 2024). GIs are promoted as instruments of rural development, and case studies associate them with price premiums, wider market access and protection of traditional knowledge (Jena et al., 2015; Menon and Vasanthakumari, 2022; Dogan, 2024; Saikia et al., 2024). Those gains depend on producer organisation, registration of users and credible quality control (Wang et al., 2021).

Most evaluations of Indian GIs begin after registration and ask whether producers gained; the specification itself, the legal text that fixes what is protected and where, has received little scrutiny. For plant products the specification may also carry statements about health. Once advertised in the official GI Journal, such statements acquire a governmental setting, although the GI system was not designed to assess health claims and India's food-claims regulation targets labelled foods rather than fresh produce (FSSAI, 2018). How health claims enter GI specifications, and how well the geographical and quality evidence behind a plant GI holds up, has not been examined for any Indian registration.

Magahi paan is the betel leaf of the Magadh region of southern Bihar. It is grown under thatched conservatories (*bareja* or *baroj*), mainly by small growers of the Chaurasia community, in Aurangabad, Gaya, Nalanda and Nawada districts (Das et al., 2018a; Vivekanand et al., 2021). It was registered as GI No. 554 in Class 31 in 2018, with protection dating from the filing of 20 June 2016, and the registration was renewed in 2026 (GI Registry, 2026). Peer-reviewed work on the cultivar is thin: agronomic reports from the Betelvine Research Centre at Islampur (Das et al., 2018a, 2018b), a survey of grower constraints (Vivekanand et al., 2021) and an in-silico docking study (Singh Nadkar Narayan et al., 2023). The public prosecution file of the application, however, is complete from filing to renewal and allows the construction of a plant GI to be examined step by step.

This study combined primary field data with an audit of that file, reading its health claims through both classical Ayurvedic texts and biomedical evidence. It asked four questions. Who applied, and how were standing and governance constituted? How did the specification change during examination, how does it compare with practice observed in the field, and on what evidence did its quality and health claims rest? How accurately was the production territory delimited? And what obligations did registration create, and what can be observed a decade later?

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2. MATERIALS AND METHODS

2.1 Study design

The study used a mixed-methods design. Primary data were collected through field visits, grower interviews and direct observation in the production area (Section 2.2). They were combined with a qualitative document analysis (Bowen, 2009) of the prosecution file of GI Application No. 554, using directed content analysis with an a priori codebook (Hsieh and Shannon, 2005); with quantitative verification of the numerical content of the documents (dates, specification values, coordinates and counts); and with a structured map of the evidence behind each health claim, read through both classical Ayurvedic and biomedical sources. For each document we asked what it asserted, on what evidence, and how the assertion differed from the previous version and from practice observed in the field.

2.2 Field visits, grower interviews and direct observation

Primary data were collected by the authors in March 2025 during field visits to Magahi paan growing villages in one of the four districts of the GI area (Aurangabad) [Block Deo and 4 villages namely Khemchand Bigha, Teju Bigha, Ketaki and Khandiha]. Face-to-face interviews were held with 27 growers, reached by snowball sampling because growers are dispersed and hard to reach, an approach used in other GI field studies (Dogan, 2024). Interviews followed a structured schedule covering the grower's profile, cultivation and marketing practice, costs, family labour, awareness of the GI, training, subsidies and environmental problems (Supplementary File S2). Cultivation and post-harvest practices were observed directly at the conservatories visited and documented photographically by the authors, and the observations were compared step by step with the method-of-production section of the advertised specification (D8). This paper reports the observational component of the field work; the quantitative analysis of the interview responses will be reported separately.

2.3 Documentary corpus

The corpus comprised ten documents issued or received by the GI Registry between June 2016 and May 2026 (**Table 1**), obtained from the Registry's public e-register for Application No. 554 together with its online status record (GI Registry, 2026). They run from the original Form GI-1, through the Registry's formality check (Rule 31) and examination report (Rule 33) and the applicant's replies, to the advertisement in Geographical Indications Journal No. 101 (GI Registry, 2017), the certificate and the renewal papers. Text was extracted from born-digital pages with Poppler pdftotext, and scanned pages were read from page images. Every quotation and value reported here was traced to its page in the source document. Documents are cited by the codes D1–D10 given in Table 1.

Table 1. Documents analysed from the file of GI Application No. 554 (Magahi paan)

Code	Date	Document (issued by)	Use in this study
D1	20 Jun 2016	Form GI-1 with statement of case, filed as "Maghai Paan" (Bihar Agricultural University, BAU)	Baseline specification
D2	20 Jun 2016	Fee receipt CBR No. 3046 for Applications 551–554 (Registry)	Filing context
D3	24 Jun 2016	Formality check report under Rule 31 (Registry)	Deficiencies; standing of applicant
D4	18 Jul 2016	Reply to formality check (BAU)	Second version; first coordinates
D5	6 Oct 2016	Examination report under Rule 33 (Registry)	Objections; post-registration conditions
D6	7 Dec 2016	Reply to examination report with amended Form GI-1, producer list, map and soil report (Samiti, prepared on behalf of BAU)	Third version; medicinal claims; roster
D7	8 Feb 2017 (on file 14 Feb 2017)	Submission of the Samiti's society registration certificate (Samiti)	Legal formation of applicant
D8	28 Nov 2017	Geographical Indications Journal No. 101, pp. 69–77, advertisement under Rule 41(1) (Registry)	Published specification; coordinates
D9	18 May 2018	Certificate of Registration No. 313 (Registry)	Proprietor; class; date of registration

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Code	Date	Document (issued by)	Use in this study
D10	22 May 2026	Renewal: covering letter and Form GI-4 (BAU and Samiti)	Stewardship after ten years

Samiti: Magahi Paan Utpadak Kalyan Samiti, Dheuri, Nawada. Registry: Geographical Indications Registry, Chennai.

2.4 Coding framework

The codebook followed the statutory content of an application under Section 11 of the Act and Rule 32(1) of the Rules (Government of India, 1999, 2002) and the deficiencies raised by the Registry in D3 and D5. It had eight parent codes: applicant and standing; description and specification of the goods; uniqueness; method of production; link between quality and geography; geographical area and map; producers; and inspection structure. A ninth code captured health or medicinal statements. Each version of the application (D1, D4, D6 and D8) was coded in full, and every coded statement was classed as new, unchanged, modified or deleted relative to the preceding version. For each claim we recorded the evidence offered (none, narrative, cited publication or measured data) and, for cited publications, whether they had been peer reviewed.

2.5 Quantitative checks

Prosecution intervals were counted in calendar days from the filing date, and specification values were tabulated across the four versions. For the geographical audit, the 52 village coordinates advertised in D8 were tested for point-in-polygon membership against Census of India 2011 district boundaries (DataMeet, 2026) using shapely 2.2 in Python 3.13. For each village we recorded the district in which its coordinate falls, the great-circle distance to the boundary of the district under which it is listed (haversine formula, mean Earth radius 6,371.0088 km) and the distance to its nearest listed neighbour. Points lying less than 0.3 km outside the listed district were classed as within boundary tolerance, because generalised district polygons cannot resolve such distances. Exact duplicates, near-duplicates (<200 m apart) and pairs sharing one identical coordinate value were flagged. The same tests were applied to the coordinates in the earlier versions (D4 and D6). Entries in the producer roster attached to D6 were counted by district, surname and honorific.

2.6 Mapping the evidence behind health claims

Each of the 12 medicinal statements published in D8 was searched in PubMed and in recent reviews of *P. betle* (Madhumita et al., 2020; Nayaka et al., 2021; Biswas et al., 2022) in October 2026, combining "Piper betle" or "betel leaf" with terms for the condition or action claimed. The highest tier of evidence for the use as claimed was recorded on a four-level scale: traditional use only; laboratory (in vitro or compositional); animal (in vivo); and human (clinical). Evidence on a related but different endpoint was recorded as adjacent, and evidence pointing in the opposite direction was flagged; no pooling or risk-of-bias scoring was attempted. Each claim was also read against the classical Ayurvedic passages on *tāmbūla*: its use as a mouth freshener in the *Caraka Saṃhitā* (Sūtrasthāna 5.76–77), its contraindications in the *Aṣṭaṅga Hṛdaya* (Sūtrasthāna 2.7) and the account of bleeding disorders (*raktapitta*) in the *Caraka Saṃhitā* (Cikitsāsthāna 4), in standard English translations (Shree Gulabkunverba Ayurvedic Society, 1949; Srikantha Murthy, 1991), and classed as concordant with, contraindicated by, or not addressed in these passages. Both readings were targeted evidence maps, not a systematic review or a survey of the whole Ayurvedic corpus.

2.7 Ethics and reproducibility

Document analysis used public administrative records and published literature. The field work consisted of non-interventional observation and interviews with adult growers. Participation was voluntary, verbal informed consent was obtained from every interviewee, and identifiable people were photographed and are shown with their permission. Names of interviewees and of individual producers in the dossier roster are not reproduced. The interview schedule and the analysis script is available from the corresponding author.

3. RESULTS AND DISCUSSION

3.1 A university filing and a producer collective formed after the fact

Bihar Agricultural University (BAU), Sabour, filed Form GI-1 on 20 June 2016 under the name "Maghai Paan", on the same day as three other Bihar applications (Nos 551–553), with the four fees paid by a single cheque (D1, D2). Within four days the Registry questioned the university's standing, asking how it qualified as an applicant under Section 11 and how the product qualified as a GI under Section 2(e) (D3). BAU replied that it provided technical support to growers (D4). The examination report of 6 October 2016 was categorical: "The University shall not be applicant", and the Registry's Consultative Group "strongly felt" that an association of producers should apply, with BAU as facilitator (D5).

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The reply of 7 December 2016 substituted the Magahi Paan Utpadak Kalyan Samiti of Dheuri, Nawada, as applicant, but its covering letter states that the amended form had been filled in on behalf of the university's Director of Research (D6). The Samiti was registered under the Societies Registration Act, 1860 only on 24 January 2017, 48 days after it had been named applicant and 218 days after the filing date, and its registration certificate reached the Registry in February 2017 (D7; **Figure 1**). The certificate of registration names the Samiti as registered proprietor, "Facilitated by: Bihar Agricultural University" (D9).

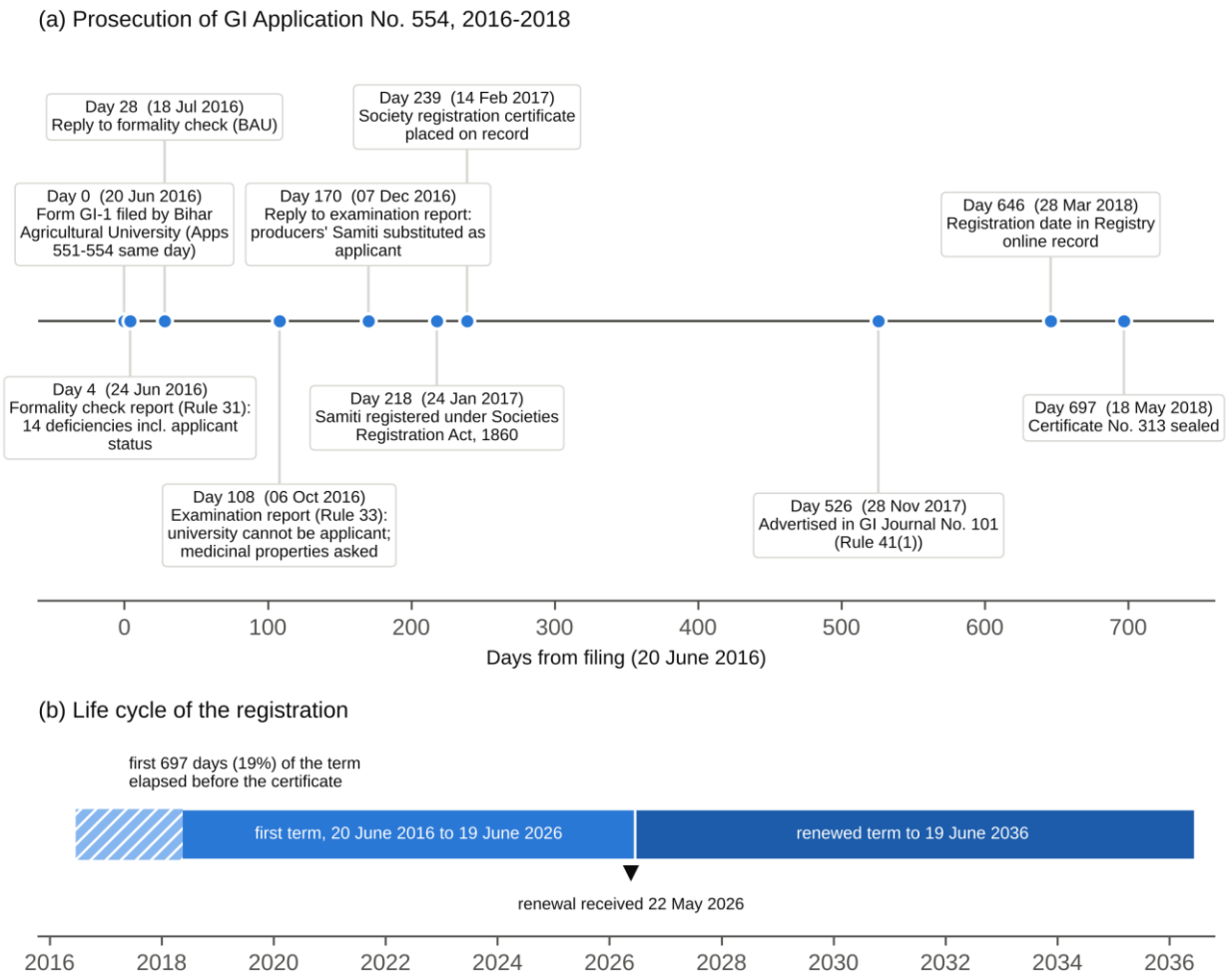


Figure 1. Prosecution and life cycle of GI Application No. 554 (Magahi paan). (a) Documented events from filing to the sealing of the certificate, in days from filing (20 June 2016). (b) Ten-year terms of protection, which run from the filing date.

The certificate was sealed on 18 May 2018, 697 days after filing, so that 19% of the first ten-year term had elapsed before the proprietor held its certificate. In May 2026 the renewal fee and Form GI-4 were again forwarded to the Registry by the university's Directorate of Research (D10).

The sequence describes a producer organisation created to satisfy Section 11 rather than one that initiated the claim. Facilitation by public bodies is common among Indian GIs and can be decisive for small producers (Menon and Vasanthakumari, 2022), but it risks leaving the collective a nominal proprietor while the facilitator controls the specification, authorised users and renewal, whereas GI benefits reach low-income farmers mainly through organisations that they run themselves (Wang et al., 2021). A decade after filing, the Samiti still relied on the university to renew its own registration.

3.2 The specification drifted during examination

The specification changed substantially between filing and advertisement (**Table 2**). The June 2016 form listed three uniqueness traits (a soft, less fibrous leaf, excellent keeping quality and suitability for bleaching), gave a keeping quality of 10–15 days for fresh leaf and one month for bleached leaf, contained no chemical data and no medicinal statements, and left the inspection

body "to be decided" (D1). Asked to compare Magahi paan with other betel leaves, the university replied: "Comparative study needs more time" (D4). The same reply described keeping quality as "upto 3 months as compare to other betel leaf".

Table 2. Changes in the Magahi paan specification from filing to advertisement

Element	D1 (Jun 2016)	D4 (Jul 2016)	D6 (Dec 2016)	D8 (Nov 2017)
Applicant	BAU	BAU	Samiti, facilitated by BAU	Samiti, facilitated by BAU
Villages listed (with coordinates)	57 (0)	52 (42)	52 (52)	52 (52)
Keeping quality, fresh leaf	10–15 days	10–15 days; "upto 3 months" in reply	15–20 days (Bangla paan: 10–15 days)	15–20 days; "upto 3 month" in production section
Keeping quality, bleached leaf	1 month	1 month	30–35 days	30–35 days
Uniqueness claims	3	"Comparative study needs more time"	8	8
Chemical data	None	None	32 oil constituents (one market sample)	As D6
Medicinal claims	0	0	12	12
Inspection structure	"To be decided"	4 public scientists and officers	8-member committee "being formulated"	As D6
Producers named	None	List "attached"	104	Not published

BAU: Bihar Agricultural University. Area under cultivation was stated as about 439 ha in every version.

By December 2016 the uniqueness section had grown to eight claims (D6). One stated that Magahi paan keeps for 15–20 days "as compared to bangala Paan having 10-15 days", so that the figure first given for Magahi paan itself had been reassigned to the comparator. Others asserted that the leaf is sweeter than Bangla paan and the smallest of all betel cultivars, without measurements for either. The shelf life of bleached leaf became 30–35 days. All of this was advertised verbatim (D8), and the advertised text contradicts itself: the specification gives 15–20 days, whereas the method-of-production section of the same advertisement says that fully mature leaves keep "upto 3 month" and that the average leaf keeps for about one month.

The record offers a simple explanation. The specification grew in response to the examiner's prompts rather than from new measurement. The Registry asked for uniqueness, medicinal properties and a soil-test report (D5), and each request was answered with text rather than comparative data. Indian rules require the special characteristics of the goods to be stated, not to be measurable or independently verified (Government of India, 2002). The European Union's GI regulation, by contrast, expects product specifications to be checked against verifiable criteria by designated control authorities or bodies (European Union, 2024). A specification that cannot be measured cannot separate genuine Magahi leaf from the other leaf sold beside it, and growers report losing ground to Calcutta and Desi varieties in the same markets (30 Stades, 2021).

3.3 What the field shows: conservatories and cultivation

The field visits allowed the practices written into the specification to be seen directly (**Figure 2**, **Figure 3**). Conservatories stood as discrete walled enclosures in open fields, their walls of dried stalks and straw tied to bamboo poles and entered through a low opening; older walls were patched with discarded cloth (Figure 2a, b; Figure 3a, b). In March, ahead of the April–July planting window given in the specification, growers were building new conservatories: bamboo frames carried a straw-lattice roof, stakes were already set in rows, and bundles of straw and split stakes were stockpiled for thatching and staking (Figure 3c–e). Planting was done by hand on ridges under the roof, each cutting pressed into the soil and mulched with straw (Figure 2d, e), and irrigation was entirely manual, with water carried in pots along the rows (Figure 2f), consistent with the watering-can method in the specification and not with sprinklers. In established conservatories each vine climbed its own reed or bamboo stake along raised ridges separated by narrow drainage channels, and older lower leaves were stripped (Figure 2c; Figure 3f, g). In older stands long stems lay along the ridges (Figure 3h), consistent with the lowering of vines for rejuvenation that the specification describes, and many vines were leafless and brown at the end of winter (Figure 3i), a reminder of the crop's sensitivity to temperatures below 10 °C recorded in the dossier (D6). Young shoots carried the glossy, heart-shaped leaves with an acute apex that the specification describes (Figure 3j).

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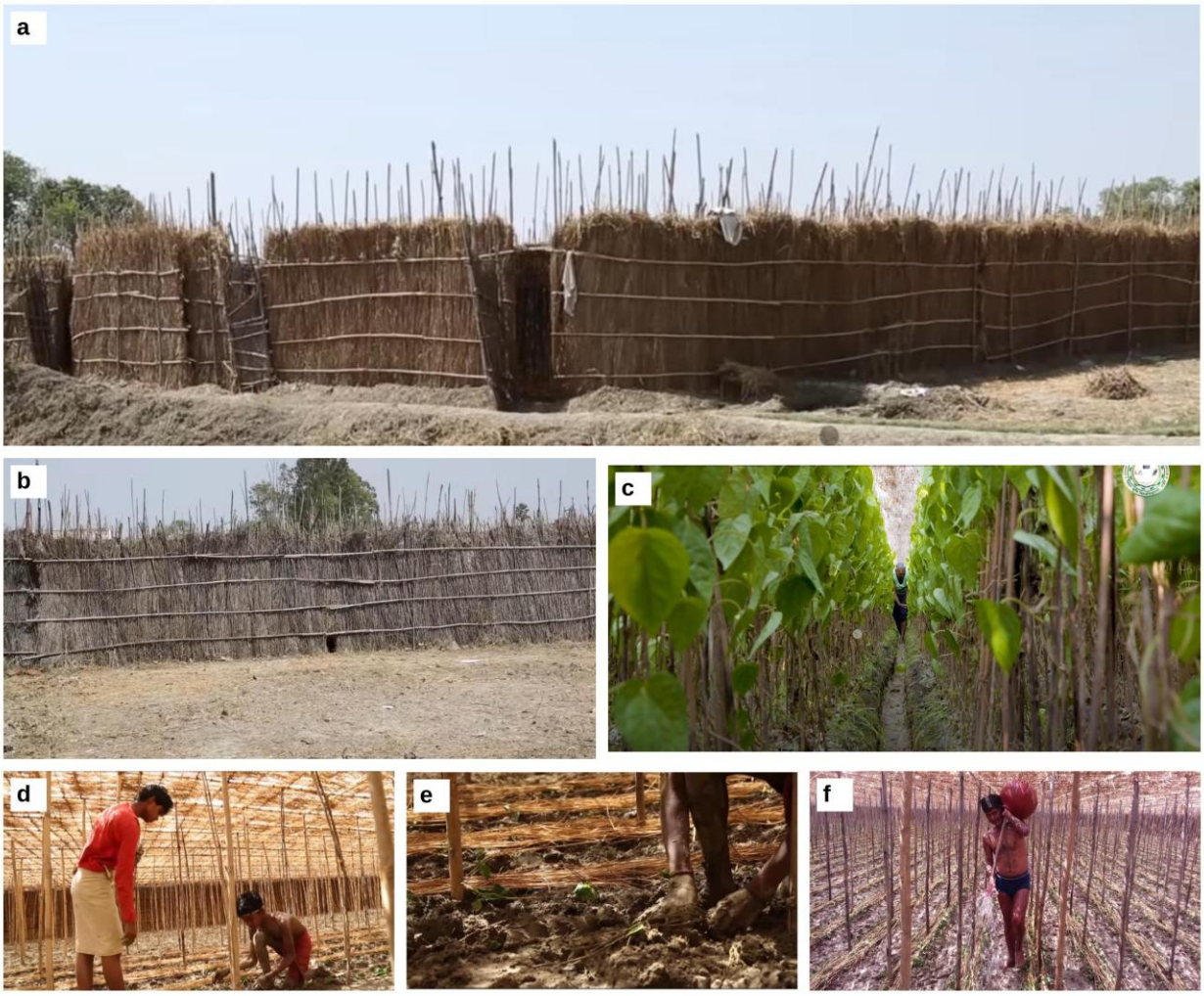


Figure 2. Field observation of Magahi paan cultivation in the Magadh region, March 2025. (a) Exterior of a conservatory (*baroj*) walled with dried stalks and straw on bamboo poles; (b) conservatory wall with its low entrance; (c) vines trained on individual stakes inside a mature conservatory, with older lower leaves removed; (d, e) hand planting of vine cuttings on ridges under the straw roof; (f) manual irrigation from a pot carried along the rows. Photographs: Ankit Raj (first author).

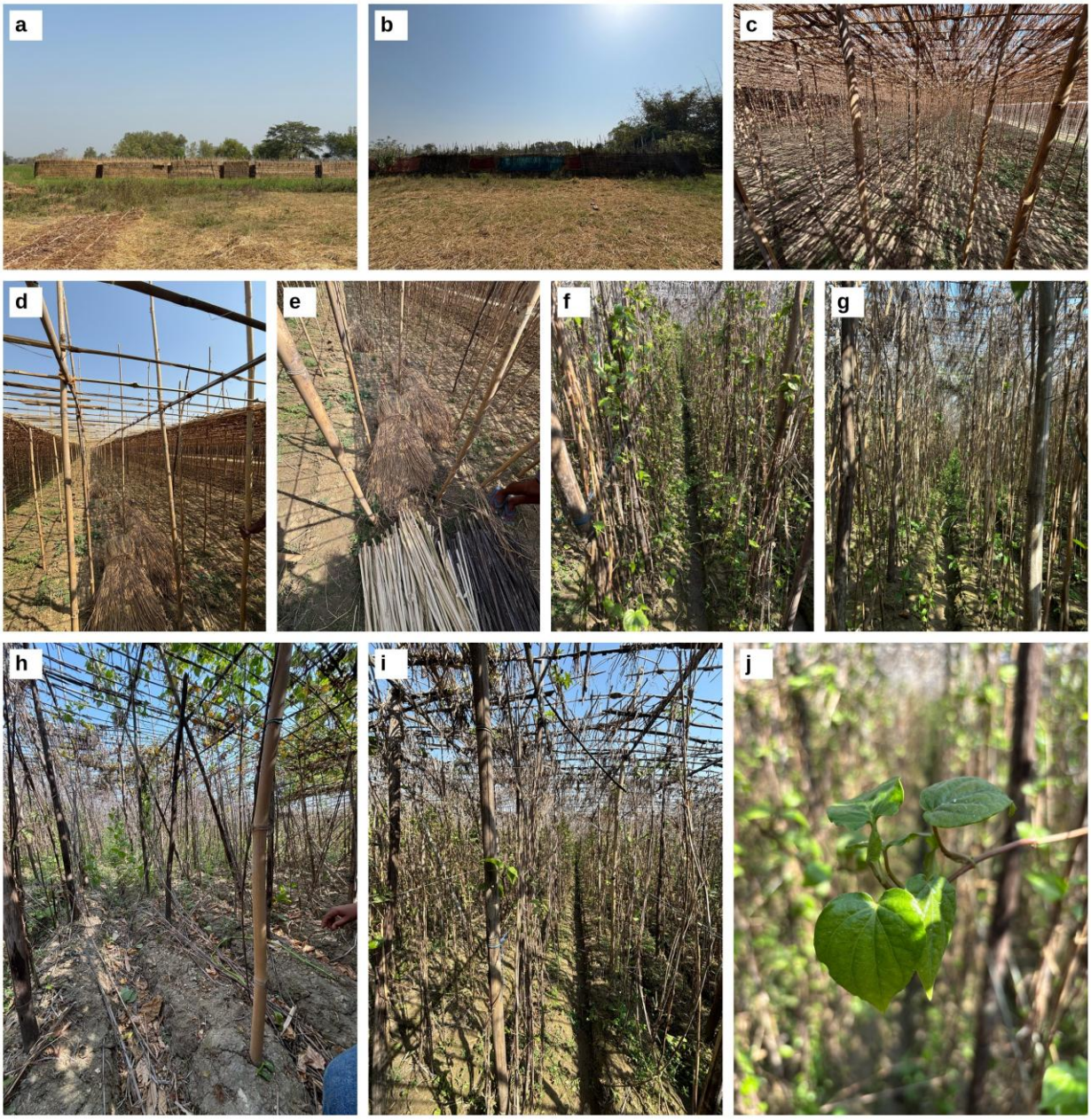


Figure 3. Conservatory construction and crop condition observed during the field visits, March 2025. (a) New conservatories (*baroj*) in open fields; (b) older conservatory wall patched with cloth; (c) interior of a newly built conservatory, with straw-lattice roof and stakes set in rows before planting; (d) bamboo roof frame under construction; (e) straw bundles and split stakes stockpiled for thatching and staking; (f, g) vines climbing reed stakes on raised ridges separated by narrow channels; (h) older stand with stems lying along the ridges; (i) largely leafless vines in an older conservatory at the end of winter; (j) young shoot with glossy, heart-shaped leaves. Photographs: Akshay Trilokinath Maurya, Ravi Raj and Manish Kumar.

One observation adds to what the documents show. The quality attributes claimed for the leaf depend on continuous hand labour, from building and re-thatching conservatories to watering, staking and stripping leaves. This labour is the "human factor adding to the quality of the product" that the Registry asked the applicant to describe (D3), and it is what climatic shocks, rising costs and the drift of young people away from the crop now threaten (Vivekanand et al., 2021; Ray and Katyayini, 2024). If the GI is to protect these growers, its specification and promotion need to reward that labour, not only the name of the leaf.

3.4 The chemical identity rests on one market sample

The only chemical evidence in the dossier is a table of 32 essential-oil constituents headed "Composition of essential oil of Magahi paan", dominated by eugenol (63.39%) and acetyleugenol (14.05%), with t-caryophyllene (4.22%), γ-carinene (3.85%) and germacrene D (2.85%) as minor components (D6, D8). The table was copied from a study of antifungal and anti-aflatoxigenic activity whose leaves were purchased from the local market of Varanasi (Prakash et al., 2010). It therefore describes a single market sample of unknown farm origin, bought in a city outside the GI territory. As advertised, the table lists aluminium sulphate, an inorganic salt, twice as an oil constituent (0.34% and 0.10%) and t-caryophyllene twice at different retention times, and the uniqueness section cites the source by its first author's given name ("Bhanu et al. 2010"); none of this was queried during examination. One of the eight uniqueness claims then attributes the pungency of Magahi paan to this oil, although no other cultivar was analysed for comparison.

Betel vine landraces do differ chemically. Indian landraces vary in essential-oil composition and antioxidant activity (Das et al., 2016), and the Bangla variety contains more chavibetol and allylpyrocatechol than the sweet and Mysore varieties (Rathee et al., 2006). Hydroxychavicol, the constituent most associated with bioactivity (Mohamad et al., 2023), does not appear in the dossier's table. A defensible chemical identity for Magahi paan would require authenticated leaf from the four districts, sampled across seasons and compared with the other cultivars traded in the same markets, with hydroxychavicol, chavibetol, eugenol and safrole quantified against reference standards. The only later chemical study of the cultivar shows why standards matter: its LC/MS screen annotated 67 constituents, and the top-ranked "phytomolecules" taken forward for docking included netilmicin, a semisynthetic aminoglycoside antibiotic, and benztropine, a synthetic anticholinergic drug (Singh Nadkar Narayan et al., 2023). Spectral library matches of this kind cannot anchor a legal specification.

3.5 Medicinal claims read through biomedical evidence and classical Ayurveda

The June 2016 application made no medicinal claims. The examination report asked that "the Medicinal characteristic / properties" be provided (D5), and the December reply inserted a list of 12 traditional uses of betel leaf, sourced to a review in a pharmacy journal and to an article in a popular magazine (Ramamurthi and Rani, 2012; Vikash, 2012). The list is generic to *P. betle*; nothing in it refers specifically to Magahi paan. It was advertised verbatim under the heading "Medicinal properties of Betelvine" (D8).

Table 3. Medicinal claims published in the Magahi paan specification, read against biomedical evidence and classical Ayurvedic texts

No.	Claim (abridged from D8)	Closest biomedical evidence	Biomedical tier	Classical Ayurvedic position
1	Leaf paste with salt and hot water for filariasis	Leaf fractions against *Brugia malayi*; immune responses in mice (Singh et al., 2009)	Animal	Not addressed
2	Leaf with *Piper nigrum* for two months for obesity	Blood glucose in diabetic rats, adjacent endpoint (Arambewela et al., 2005; Santhakumari et al., 2006)	Traditional only	Not addressed
3	Juice with honey for cough, dyspnoea and indigestion in children	Gastric protection and digestive enzymes in rats, adjacent endpoints (Prabhu et al., 1995; Majumdar et al., 2002; Bhattacharya et al., 2007)	Traditional only	Not addressed
4	Oiled leaves on the breast to promote milk secretion	None located	Traditional only	Not addressed
5	Local application for orchitis, arthritis and mastitis	Adjuvant-induced arthritis in rats (Ganguly et al., 2007)	Animal	Not addressed
6	Warm leaves with mustard oil on the chest for cough	None located	Traditional only	Not addressed
7	Removes bad breath and body odour; prevents tooth decay	Oral bacteria in vitro (Ramji et al., 2002; Sharma et al., 2009); pilot trial of a betel-leaf toothpaste (Ali et al., 2022)	Laboratory	Concordant for mouth freshening (CS Sū 5.76–77)

No.	Claim (abridged from D8)	Closest biomedical evidence	Biomedical tier	Classical Ayurvedic position
8	Treats vaginal discharge and itching	Hydroxychavicol against *Candida* species in vitro (Ali et al., 2010)	Laboratory	Not addressed
9	Stops nasal bleeding	Hydroxychavicol inhibits platelet aggregation, opposite direction (Chang et al., 2007)	Traditional only	Contraindicated: bleeding disorders (AH Sū 2.7)
10	Contains vitamins; tonic with honey	Leaf composition; tonic effect untested (Guha, 2006)	Laboratory	Not addressed
11	Juice with diluted milk eases urination	None located	Traditional only	Not addressed
12	Stimulant, antiseptic and breath freshener	Antimicrobial activity in vitro (Nayaka et al., 2021); pilot toothpaste trial (Ali et al., 2022)	Laboratory	Concordant for breath freshening (CS Sū 5.76–77)

No claim reached the human (clinical) tier for the use as stated. CS Sū, Caraka Saṃhitā, Sūtrasthāna; AH Sū, Aṣṭāṅga Hṛdaya, Sūtrasthāna. "Not addressed": not dealt with in the classical passages on tāmbūla examined (Section 2.6).

None of the 12 claims has human clinical evidence for the use as stated (**Table 3**, **Figure 4**). Two reach animal models: antifilarial activity of leaf fractions against *Brugia malayi* with immune effects in mice (Singh et al., 2009), and anti-inflammatory activity in adjuvant-induced arthritis in rats (Ganguly et al., 2007). Four reach laboratory evidence: activity against oral anaerobes and *Streptococcus mutans* (Ramji et al., 2002; Sharma et al., 2009), anti-*Candida* activity of hydroxychavicol (Ali et al., 2010), general antimicrobial activity (Nayaka et al., 2021) and vitamin content (Guha, 2006). Six rest on traditional use alone, among them claims to treat obesity, to relieve cough and indigestion in children, to promote lactation and to ease urination. For two of these the nearest experimental work concerns a different endpoint in rats (Table 3). The only human trial located compared a betel-leaf toothpaste with a miswak toothpaste in a randomised crossover pilot in 60 participants with mild gingivitis, measuring plaque and gingival indices (Ali et al., 2022); it bears on the claims about bad breath and breath freshening but tests neither leaf chewing, tooth decay nor body odour. One claim runs against the known pharmacology: the leaf is said to stop nasal bleeding, whereas hydroxychavicol inhibits platelet aggregation and thromboxane production (Chang et al., 2007).

Read through classical Ayurveda, the list looks different again (Table 3, Figure 4). Only the claims about bad breath and breath freshening match the classical use of *tāmbūla*, which the *Caraka Saṃhitā* prescribes for the cleanliness and fragrance of the mouth (Sūtrasthāna 5.76–77). The claim that the leaf stops nasal bleeding runs against the classical texts as well as against pharmacology: bleeding from the nose is a form of *raktapitta* (*Caraka Saṃhitā*, Cikitsāsthāna 4), and the *Aṣṭāṅga Hṛdaya* lists bleeding disorders among the conditions in which *tāmbūla* is unwholesome (Sūtrasthāna 2.7), consistent with the hot, *pitta*-aggravating nature ascribed to the leaf (Tiwari et al., 2025). The other nine claims are not addressed in the classical passages we examined. The dossier therefore borrowed the authority of tradition selectively: it listed benefits but left out the contraindications that the same tradition attaches to *tāmbūla*. Ayurveda also carries its own warning about the quid as consumed.

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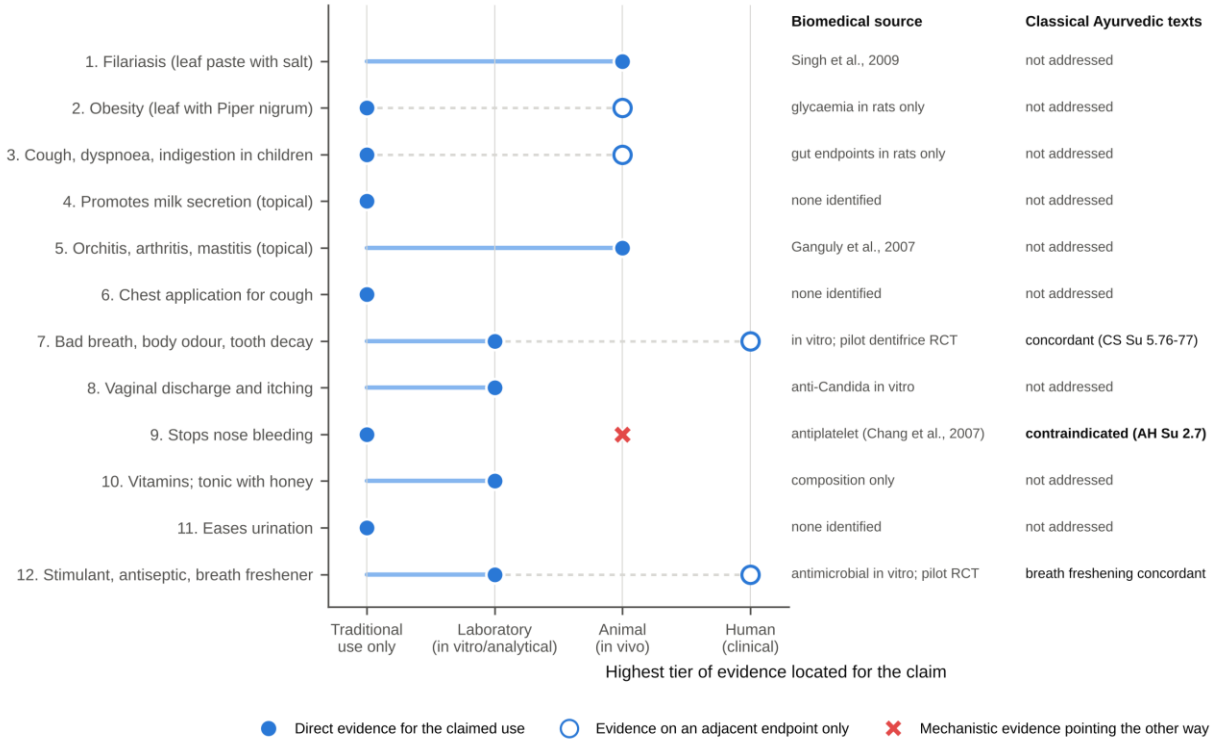


Figure 4. Highest tier of biomedical evidence located for each of the 12 medicinal claims in the Magahi paan specification, with the position of the classical Ayurvedic passages on tāmbūla. Filled circles: evidence for the use as claimed; open circles: evidence on an adjacent endpoint only; cross: mechanistic evidence pointing the other way. CS Su, Caraka Saṃhitā, Sūtrasthāna; AH Su, Aṣṭāṅga Hṛdaya, Sūtrasthāna. Claims are abridged; sources are listed in Table 3.

Its concept of incompatible combinations (*saṃyoga viruddha*) has been applied to the mixture of betel leaf, areca nut, lime and tobacco to explain its harm (Sirdeshpande and Kashikar, 2017), a reading that agrees with the IARC classification. An Ayurvedic-biology approach (Joshi et al., 2023) would keep the classical indication and contraindications together and test the indication with standardised leaf preparations.

Three consequences follow for human health. First, the Journal entry gives traditional claims an official setting that their sources lacked, although the GI examination did not assess efficacy and Indian food regulation requires health claims to be scientifically substantiated (FSSAI, 2018). Second, several claims concern children and lactating women, or internal use with other ingredients, and no safety information accompanies them. Third, and most important, the leaf is mainly consumed in betel quid. Evidence that betel leaf modifies the harm of other quid ingredients is limited and inconsistent (Cirillo et al., 2022), and promoting the leaf as medicinal sits uneasily with the Group 1 classification of betel quid and areca nut (IARC, 2004, 2012). The preclinical promise of hydroxychavicol (Paranjpe et al., 2013; Gundala and Aneja, 2014; Mohamad et al., 2023) is a reason to develop standardised extracts, not a basis for claims about chewing fresh leaf. We suggest that GI specifications confine themselves to descriptors of identity and quality and that any health statement retained be graded and referenced to peer-reviewed evidence, with the form and dose stated and the classical Ayurvedic contraindications included. Examiners could also stop treating medicinal properties as evidence of uniqueness.

3.6 The territory on the map

The application gives the production area as about 439 ha (Aurangabad 150 ha, Nalanda 125 ha, Nawada 90 ha and Gaya 74 ha), a figure that did not change between versions. The village list did: 57 villages in June 2016 became 52 in the replies, without explanation (D1, D4, D6). The July 2016 list gave no coordinates for ten villages, placed Majhwe in Saran district 159 km from its later position and gave three Nawada villages identical coordinates (D4). In the December version the latitude of Deo was entered as 29.655927°N, which places the village outside India, about 556 km north of its corrected position (D6). The formality check had asked for a map from a competent statutory authority giving the latitude and longitude of the production area (D3); none of these errors was raised before advertisement.

Table 4. Position of the 52 advertised village coordinates relative to Census 2011 district boundaries

Listed district	Villages	Inside listed district	Outside by >1 km	Outside by <0.3 km	Identical pairs	Median nearest-neighbour distance (km)
Aurangabad	14	13	Kanausi (5.4 km into Gaya)	–	0	0.87
Gaya	6	5	Harshingra (39 km into Chatra, Jharkhand)	–	0	5.99
Nalanda	16	13	–	Arjun Sarthua, Imadpur (0.27 km into Jehanabad); Kochra (0.02 km into Gaya)	1	0.29
Nawada	16	16	–	–	1	0.77
Total	52	47 (90.4%)	2	3	2	–

Identical pairs: Arjun Sarthua = Imadpur; Beldari = Daphalpura. Further pairs <200 m apart: Arora–Bhatu Bigha (85 m), Bauri Chhowana–Bauri Durgasthan (54 m), Daura–Maidikalan (172 m).

Of the 52 coordinates advertised in the GI Journal, 47 (90.4%) fall inside the district under which the village is listed (**Table 4**, **Figure 5**). Two are gross errors. Kanausi, listed under Aurangabad, plots 5.4 km inside Gaya district. Harshingra, listed under Gaya, plots 39 km beyond the Gaya boundary in Chatra district of Jharkhand, 82 km from the nearest listed village. Three Nalanda entries fall within 0.3 km of their district boundary, inside the tolerance of the boundary data, but two of them, Arjun Sarthua and Imadpur, share identical coordinates, as do Beldari and Daphalpura in Nawada. Three further pairs lie less than 200 m apart and three pairs share one identical coordinate value, a pattern more consistent with copying than with independent survey points. The listed villages extend about 150 km from west to east.

These errors matter because the territory is the basis of enforcement. The examination report made registration of authorised users conditional on a certificate that the applicant "is a producer within the GI Area of Production" (D5), and a list containing misplaced points cannot settle that question near a boundary. The historical record supports a tighter delimitation than the dossier attempted: a district gazetteer of 1906 cited in the application names Ketaki in the Aurangabad subdivision and Tungi in the Nawada subdivision as centres of betel cultivation (O'Malley, 1906), and both villages appear among the 52. We suggest redefining the GI area as village polygons drawn from official census or cadastral boundaries and publishing it as an open spatial layer that producers, inspectors and courts can consult.

3.7 Obligations after registration and what can be observed

The examination report attached three conditions to registration: producers were to be registered as authorised users with a no-objection certificate from the proprietor or BAU; a report on the impact of registration and the means of promotion was to be filed within one year; and a logo was to be supplied (D5). The public file contains no impact report and no logo, and the inspection committee described in December 2016 as "being formulated", with two grower seats out of eight, is not documented as having been constituted (**Table 5**). The two inspection proposals in the file also differ: the July 2016 version named four government scientists and officers and no producers (D4).

Outside the file, the Indian Council of Agricultural Research reports that 1,001 growers have been registered as authorised users and that a producer company was registered in Hisua block, Nawada, in September 2023 (ICAR, 2026). All of these authorised users come from Nawada and Nalanda, the districts of the proprietor and of the facilitating research station; none is reported from Aurangabad or Gaya, which account for 224 of the 439 ha (51%) of the declared area. The roster attached to the application listed 104 producers, 56 of them with the surname Chaurasia and 11 entered with the honorific "Smt.", which denotes women. No gender-disaggregated data on authorised users were found.

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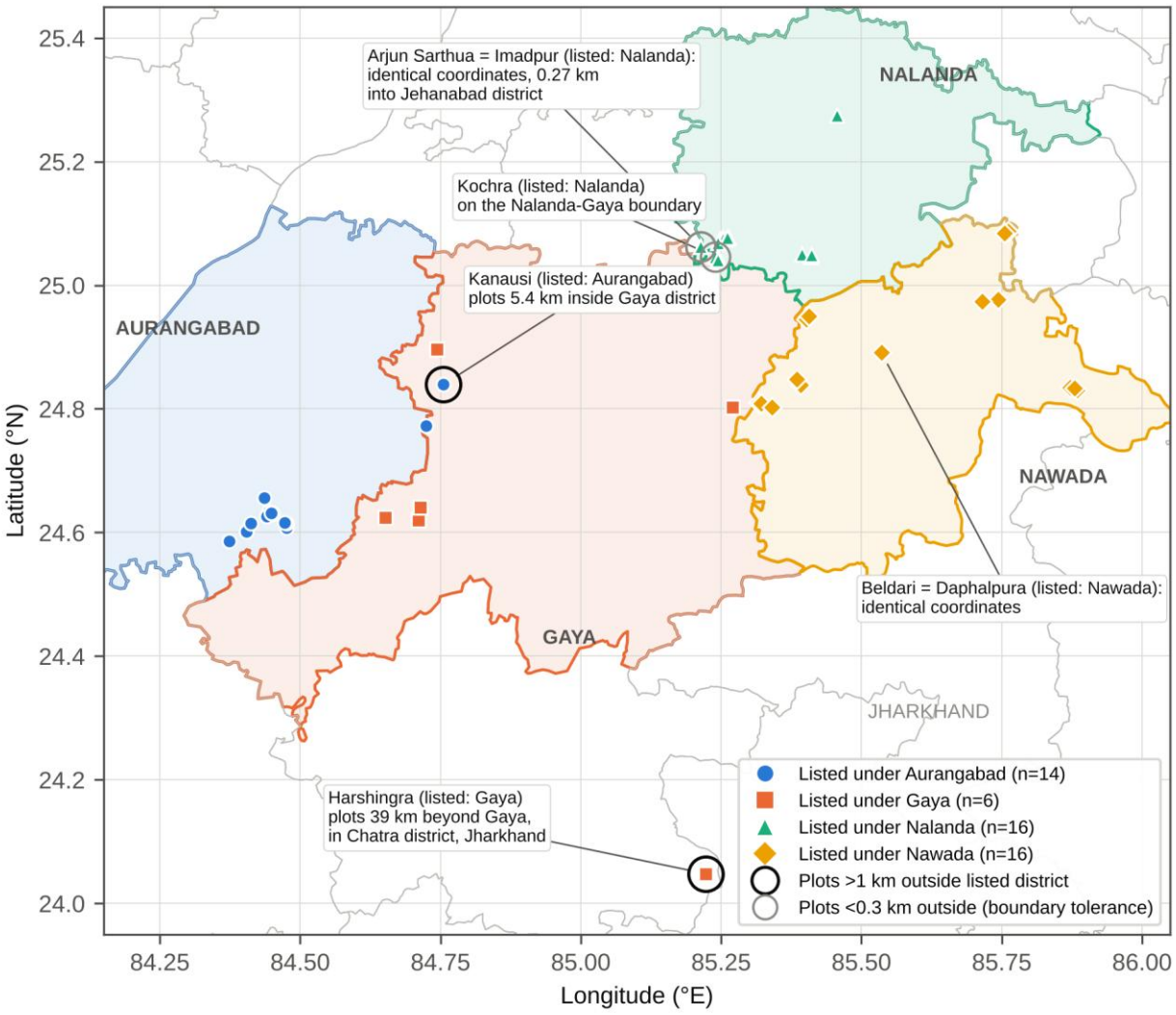


Figure 5. Published coordinates of the 52 Magahi paan production villages (GI Journal No. 101) on Census of India 2011 district boundaries (DataMeet, 2026). Marker colour and shape show the listed district. Black rings: points >1 km outside the listed district; grey rings: points <0.3 km outside it, within boundary-data tolerance. Pairs with identical coordinates are labelled.

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Table 5. Post-registration obligations and the evidence available in October 2026

Obligation	Source	Evidence found	Status
Register producers as authorised users, each with a no-objection certificate	D5	1,001 authorised users, all from Nawada and Nalanda (ICAR, 2026)	Partial; none reported for Aurangabad or Gaya
Report on the impact of registration and promotion within one year	D5	No report in the public file	Not evidenced
Logo for identification of the GI	D5	Not among the enclosures to D6; none in the file	Not evidenced
Inspection structure (Rule 32(1)(g))	D1, D4, D6	Committee "being formulated" in D6; no constitution, procedure or report in the file	Not evidenced
Renewal before expiry (Section 18)	Act	Form GI-4 received 22 May 2026, forwarded by BAU (D10)	Met

Evidence on economic outcomes conflicts. ICAR reports that prices rose to about INR 280–300 per *dholi* of 200 leaves, from INR 120–140 in earlier years (ICAR, 2026); the original application gave a range of INR 50–200 per *dholi* depending on variety, quality and season (D1). These are nominal, grower-reported figures without a comparison group. Journalistic accounts from the same villages quote growers who say that the GI has not helped, describe competition from Calcutta and Desi leaf, report heat-wave losses in Nawada in June 2023 when the Warisaliganj station recorded 45.9 °C, and note compensation of about INR 126 per *cottah* because betel leaf, classed as horticulture, falls outside crop insurance (30 Stades, 2021; Ray and Katyayini, 2024). An on-station trial obtained 20.45–27.25 lakh marketable leaves ha^{-1}, about half the 50–60 lakh ha^{-1} stated in the specification (Das et al., 2018b). The state's Paan Vikas Yojana now offers growers a 50% subsidy on the unit cost of betel cultivation (Patna Press, 2025; ICAR, 2026). As studies of other GIs have found, registration is a precondition for such benefits rather than a substitute for them (Jena et al., 2015; Wang et al., 2021; Dogan, 2024).

3.8 Limitations

The field work covered one month (March 2025) and 27 growers reached by snowball sampling, so it describes practice in the villages and markets visited but cannot estimate how common that practice is or represent the 1,001 authorised users; the photographs illustrate rather than measure, and the interview responses are not analysed here. We did not sample leaf or measure its chemistry, so the analysis establishes what the dossier claims and on what evidence, not the true properties of Magahi paan. The public e-register may not contain every paper exchanged with the Registry, and the absence of a document from the file does not prove that a step was never taken. The evidence map was structured but not systematic, the Ayurvedic comparison was confined to the classical passages on *tāmbūla* in standard translations, and the post-registration outcomes were drawn from institutional and journalistic sources whose accounts disagree. Coding followed an explicit codebook and every coded statement was checked against its source page, but no inter-coder reliability statistic was computed.

4. CONCLUSION

The Magahi paan GI protects a name, a list of villages and a set of cultivation practices, but it certifies much less about quality and health than its specification suggests. Field visits across the one of the GI districts confirmed that the leaf is still grown by labour-intensive conservatory methods, and that this hand labour carries much of the quality the GI protects. The applicant collective was registered after it replaced the university that drafted the claim; keeping-quality and uniqueness claims drifted without measurement; the essential-oil profile came from one market sample bought outside the territory; and the twelve medicinal claims entered at the examiner's request from secondary sources, with no human evidence for any use as stated. Read through classical Ayurveda, only the oral-hygiene uses are supported, and the same tradition contraindicates *tāmbūla* in the bleeding disorders that one published claim says the leaf treats. One in ten advertised coordinates lies outside its listed district, and no inspection body is documented. The 2026 renewal is an opportunity to correct these weaknesses through (i) a chemical reference profile of authenticated Magahi leaf, with hydroxychavicol and related phenolics quantified against standards; (ii) an openly published, polygon-based map of the GI area; (iii) evidence-graded health statements that carry the classical Ayurvedic contraindications and are separated from betel-quid use; (iv) an inspection body with a producer majority; (v) authorised users

in Aurangabad and Gaya, with gender-disaggregated records; (vi) a registered GI logo on *dholi* bundles at sale; and (vii) crop insurance for betel vine. Analysis of the interview data collected for this study will help to measure what the GI has changed for growers. For plant products with medicinal reputations, GI examination should test claims of quality and health as rigorously as it tests claims of origin.

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AUTHOR CONTRIBUTIONS

Ankit Raj: Conceptualization, Investigation (field visits, grower interviews and photography), Data curation, Writing – original draft, Project administration.

Akshay Trilokinath Maurya: Methodology, Investigation (field visits and photography), Formal analysis, Visualization, Writing – review & editing.

Ravi Raj: Investigation (field visits and photography), Validation, Writing – review & editing.

Manish Kumar: Investigation (field visits and photography), Validation, Writing – review & editing.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS STATEMENT

The documentary analysis used publicly available records and published literature. The field component involved non-interventional observation and interviews with adult growers in March 2025. Participation was voluntary and verbal informed consent was obtained from every interviewee; identifiable people are shown in the photographs with their permission. No animals were involved.

DATA AVAILABILITY STATEMENT

The documents analysed are available from the public e-register of the Geographical Indications Registry (Application No. 554). The interview schedule and interview responses and the original field photographs are held by the corresponding author and will be shared on reasonable request, subject to participant confidentiality.

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