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Original Article

Building an Herbarium Unit: from collection to curation - A guide for botanical research and conservation

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Abstract: The study presents a comprehensive framework for establishing a functional herbarium unit, highlighting its vital role in plant biodiversity research and conservation. To this end, an effort has been made to outline the steps for setting up a national-level herbarium, drawing on insights gained from visits to regional herbaria in Maharashtra, Himachal Pradesh, Odisha, Haryana, and Bihar. The experiences and knowledge collected from these visits are synthesized and presented in this manuscript to guide the development of an effective herbarium unit. The required components and step-by-step procedures are systematically detailed to provide a clear roadmap for herbarium establishment. This paper will serve as a valuable resource for researchers, students, scientists, and nature enthusiasts, supporting herbarium development, education, public awareness, and botanical conservation.

Keywords: Herbarium, plant biodiversity, botanical collection, taxonomy, plant identification, mounting, accessioning, field data, curation, molecular integration, DNA barcoding, botanical research, sustainable utilization

Introduction

Botanical gardens serve as living repositories of plant diversity, showcasing species from diverse regions and habitats (Giovanetti et al., 2020; Rawat et al., 2025). However, not all plants can thrive under artificial conditions. To preserve the identity and scientific value of such species, herbarium units function as permanent archives of dried plant specimens (Kozlov et al., 2021), each carefully mounted and accompanied by detailed data labels (Bebber et al., 2010). These specimens are invaluable resources for plant identification, taxonomy, conservation, and education (Jain and Rao, 1976). A well-maintained herbarium not only documents regional and global biodiversity but also provides essential reference material for researchers, teachers, and students (Eckert et al., 2024). Many botanical gardens maintain dedicated herbarium sections where extensive collections are continuously curated. Herbarium specimens play a pivotal role in the conservation of plant species (James et al., 2018). Specimens collected by research staff from various locations contain critical information such as habitat, local names, vegetation type, diagnostic characters, flower structure, and color, all meticulously recorded on specimen labels. These records are indispensable for accurate plant identification, teaching botany at undergraduate and graduate levels, and supporting diverse research activities (Jena et al., 2025). The role of scientists and taxonomists is crucial in overseeing the curation and maintenance of herbarium units. Herbarium deposition exists at different levels like international, national, regional, institutional, and industrial, each represented by specific acronyms. The Royal Botanic Gardens, Kew (London) houses a vast collection of herbarium specimens and is represented by the acronym “K” (Walker et al., 2022), while the Central National Herbarium in Kolkata is abbreviated as “CAL.” Recognizing the importance of herbarium units, this article presents practical insights on establishing a functional herbarium. The authors visited regional herbaria and share their experiences and knowledge here to guide the development of an efficient herbarium unit. This paper will serve as a valuable resource for nature enthusiasts, students, researchers, and professionals interested in plant studies, education, and conservation.

Essential infrastructure and equipment

To establish an Herbarium Unit (Figure 1), the following infrastructures and equipment are required as an initial step ((Jain and Rao, 1976; Jena et al., 2025):

a) An air-conditioned room for the Herbarium deposition area.
b) A customized pigeon-Hole cupboard (Figure 2), preferably made of steel.
c) Dryers or Drying Chambers.
d) A customized wooden herbarium press.
e) Naphthalene balls.
f) Blotting Papers.
g) Genus Covers.
h) Species Covers.
i) Mounting Sheets.
j) Mounting Boards.

k) Identification slips.

l) A logbook.

Figure 1: A model Herbarium Unit

Figure 2: Pigeon-Hole Cupboards for Herbarium, designed to hold a single herbarium sheet or a folder containing multiple sheets

The overall process of preparing an Herbarium and the on-going process is listed and briefly described here under:

1. **Botanical collection**: This can be divided into collection trips, exploration trips, and expedition trips.
2. **Travel arrangements**: Organizing accommodations and basic requirements of the journey.
3. **Materials and equipment**: Ensuring that the necessary materials and equipment are carried for the trip.
4. **General instructions**: Providing guidelines and safety precautions to be followed during the trip.
5. **Collections of specimens**: Gathering plant samples from the field.
6. **Field data recording**: Documenting field data in the Field Data Note Books.
7. **Pressing and drying**: Using blotting paper or old newspaper and a press to dry plant specimens.
8. **Changing blotting paper**: Replacing blotting paper or newspapers used during the pressing of specimens.
9. **Poisoning**: Applying poison to the plant specimens for preservation.
10. **Preserving specimens**: Maintaining the botanical specimens in a suitable condition.
11. **Mounting**: Attaching the dried, pressed, and poisoned specimens to mounting materials.
12. **Glueing**: Using glue to secure the plant specimens in place.
13. **Stitching**: Sewing the plant specimens to keep them intact.
14. **Labelling**: Clearly labelling each herbarium specimen for identification.
15. **Identification**: Determining the botanical identity of a plant specimen.
16. **Filing**: Organizing the herbarium specimens using accession numbers.
17. **Arrangement**: Structuring the herbarium specimens within the organization's herbarium unit.
18. **Miscellaneous section**: Setting up a section for undetermined specimens, plant duplicates, unmounted duplicates, and resources for beginners, etc.
19. **General maintenance**: Providing ongoing instructions for the upkeep and management of herbarium activities.

The following steps are necessary for the preparation of an herbarium specimen:

1) Planning for a botanical collection typically begins with organizing a collection trip, exploration trip, or expedition trip. This initial step is crucial for building an herbarium from a specific region. The planning and arrangement of the trip depend upon various factors, such as the duration and purpose of the work involved.

2) Some important equipment required for the collection trip are camera, secateurs, knife, trowel, polyethene bags, vasculum, raincoat, field note books, flora books, clothes, first aid box, food stuffs, pencils, eraser, pens, thread & needle, scale, pocket lens, old newspapers, blotting paper, field presses, ropes, soaps, identity cards, torch with batteries, binoculars, GPS tracker, lighter, candles, shoulder bags, leech guard, graph paper, wring board, water bottles, and black coloured papers.

3) Stay, journey, and/ or camping arrangements should be well planned. Instructions and precautions must be clearly communicated before the trip.

4) When collecting herbarium specimens (Figure 3), choose a healthy twig or branch of a plant that has flowers, leaves and/or fruits. The size should not exceed the dimensions of the mounting paper, which is (28 x 42) cm.

5) For herbaceous plants, the whole plant should be collected. It is also important to collect duplicates from the same location with GPS coordinates (Figure 4).

6) If immediate pressing is not possible, plant parts can be collected and kept in a vasculum with a small amount of moisture to keep them fresh. Many times, polyethene bags are used in place of vasculums because they are lightweight and easy to carry. The collected plants can be placed in a polyethene bag and tightly sealed to maintain freshness until they can be pressed and dried.

7) A field number is allotted, and field data is recorded in a field data book (Figure 5). This includes information such as the date, local or vernacular name, locality, GPS coordinates, habitat, vegetation, a description of the collected plant, and the collector's name.

8) The next step involves pressing and drying of the plant specimen. The collected plant part is cleaned, and dirt or mud is removed, and then spread cautiously to display both sides of the leaves and flowers. Care should be taken to avoid overlapping as much as possible.

9) If the plant specimen is longer than the mounting sheet, bend it in a V, N, M or W shape between the bloating paper or newspaper and later pressed using an herbarium press (Figure 6).

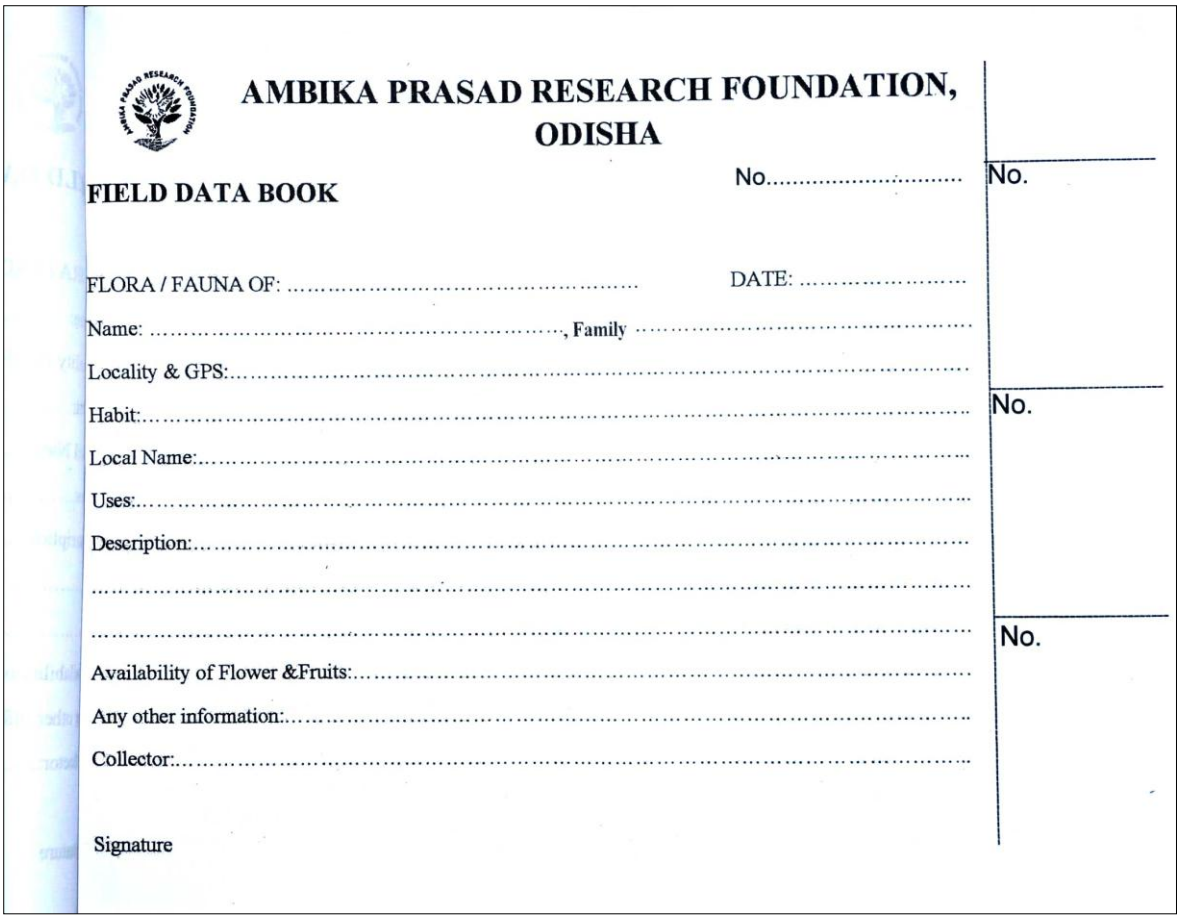
10) The blotters are changed every day for 6-10 days or until the plants are fully dry and ready for mounting. In humid weather conditions or tropical environments, dryers or drying chambers may be used.

11) Mercuric chloride is used for poisoning, and the liquid preservatives are utilized in embryological or anatomical studies consist of a combination of 95% ethyl alcohol (50 cc), glacial acetic acid (5 cc), 40% formaldehyde (10 cc) and water (35 cc). It is advisable to poison the plant specimen as soon as possible after collection.

12) If immediate poisoning is not feasible, dried specimens can typically be treated by submerging the entire plant in a solution of mercuric chloride ($MgCl_2$) in ethanol, in a ratio of (1:9), in a tray or tub for 15-20 seconds, depending upon the thickness of the specimen.

Figure 3: Field activities for the preparation of an herbarium specimen. (a) collection of plant specimens, (b) sandwiching the specimen between sheets of blotting paper

Figure 4: Global Positioning System (GPS) Device



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FIELD DATA BOOK

No.....

No.

FLORA / FAUNA OF: ..... DATE: .....

Name: ....., Family .....

Locality & GPS:.....

Habit:.....

No.

Local Name:.....

Uses:.....

Description:.....

.....

.....

No.

Availability of Flower &Fruits:.....

Any other information:.....

Collector:.....

Signature

Figure 5: A sample of field data book

Figure 6: An herbarium press

Figure 7: Pasting of a plant specimen using glue

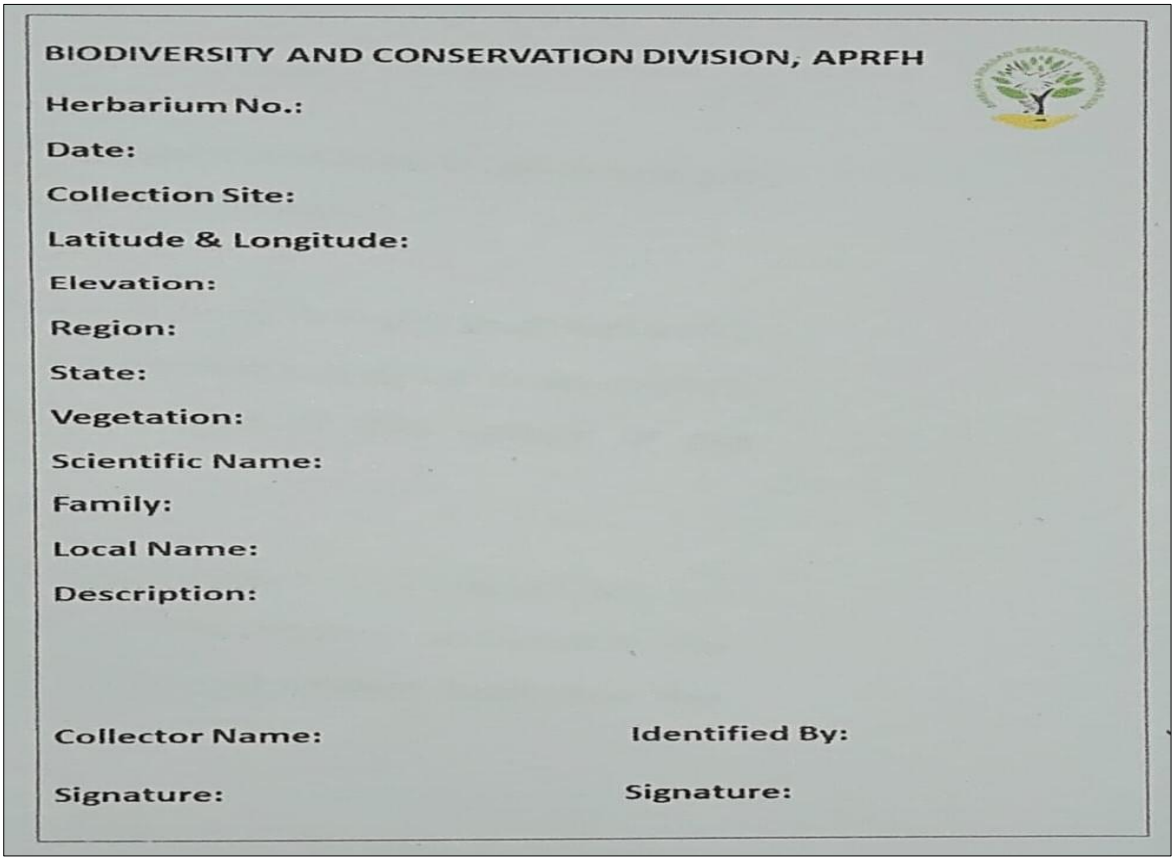

Figure 8: A sample of herbarium label approximately 8 x 12 cm in size

13) The treated specimen should then be dried in a press for several hours. Poisoning can also be carried out after mounting the specimen, using a brush. Other preservatives, such as Lauryl pentachlorophenate (LPCP) and formalin, may also be used.

14) Additionally, fumigation with toxic volatile liquids like methyl bromide, carbon disuphide, or carbon tetrachloride is also used to eliminate pests from the plant specimen.

15) Once the plant specimen is dried, pressed, and poisoned, it should be mounted on a mounting sheet measuring 28 x 42 cm (± 1 cm). The specimen should be neatly spread on the mounting sheet, ensuring that all parts of the plant are visible. After positioning the specimen, it should be glued down using a brush (Figure 7).

16) It is important to leave enough space on the right side at the bottom of the sheet for labelling, making sure that no part of the plant overlaps with the label. To secure the stem, small stitches can be made.

17) This involves piercing a hole on each side of the stem or twig and threading a durable thread through a needle to create independent stitches. The same process is followed for fruits or large seeds. Small seeds can be placed in small pockets that are glued onto the mounting sheet.

18) Plant identification is the next step when a plant cannot be easily identified by its characteristics. Scientific methods should be followed, which involve identifying key characteristics, comparing them with descriptions and illustrations from authenticated records, and matching them with related herbarium specimens worldwide. If the characters do not match, this may indicate the discovery of a new taxon, allowing for necessary publications to be produced afterwards.

19) Plant identification and determination is a continuous process, especially when the plant does not fit any satisfactory match or identity. Annotation slips, also known as determination slips, are attached to the herbarium sheet during reidentification.

20) This slip should include the new name of the plant specimen, the date, and the name of the person who assigned the new name. It may also include comments referencing the publication related to the reidentified specimen.

21) An herbarium specimen is incomplete without a herbarium label, which should be approximately 8 x 12 cm in size.

22) The label must include the following details: family, genus, and species; GPS location of the collection; date of collection; a brief description of the plant or any relevant notes; the collector’s name; local or vernacular name; the name of the organization or institution; and the voucher number (Figure 8).

23) The preparation of the herbarium specimen begins with assigning an accession number to the specimen, which must be dried, pressed, poisoned, mounted, glued, stitched, and labelled. A register is maintained to record the list of accession numbers for different specimens, including the date and stamp of the institution or organization.

24) Herbarium specimens are arranged according to an accepted system of classification. Bentham and Hooker's system of classification is commonly used in many Indian Herbaria for its convenience.

25) After the accession number is assigned, herbarium specimens are organized into their respective species, genus, and family covers or folders.

26) A species cover is a light cover specific to a single species, while a thicker genus cover accommodates different species within a single genus. Similarly, a family cover is designated for specimens belonging to a single family. These covers are then arranged in a pigeonhole cupboard.

27) A separate section for miscellaneous herbarium sheets should be kept for cultivated plants, unmounted specimen duplicates, and bulky herbarium specimens, especially when frequent visits are made by students, beginners, or inexperienced individuals.

28) This is important to maintain the integrity and prevent damage to the herbarium specimens.

Using the above all steps, we can get a good quality of *Herbarium Specimen* (Figure 9) and then can keep in a developed national level Herbarium Unit. These specimens will be valuable for many purposes (Figure 10-14). However, authors provided a set of general instructions for the curator or In-charge of Herbarium Unit. In details, discussed below.

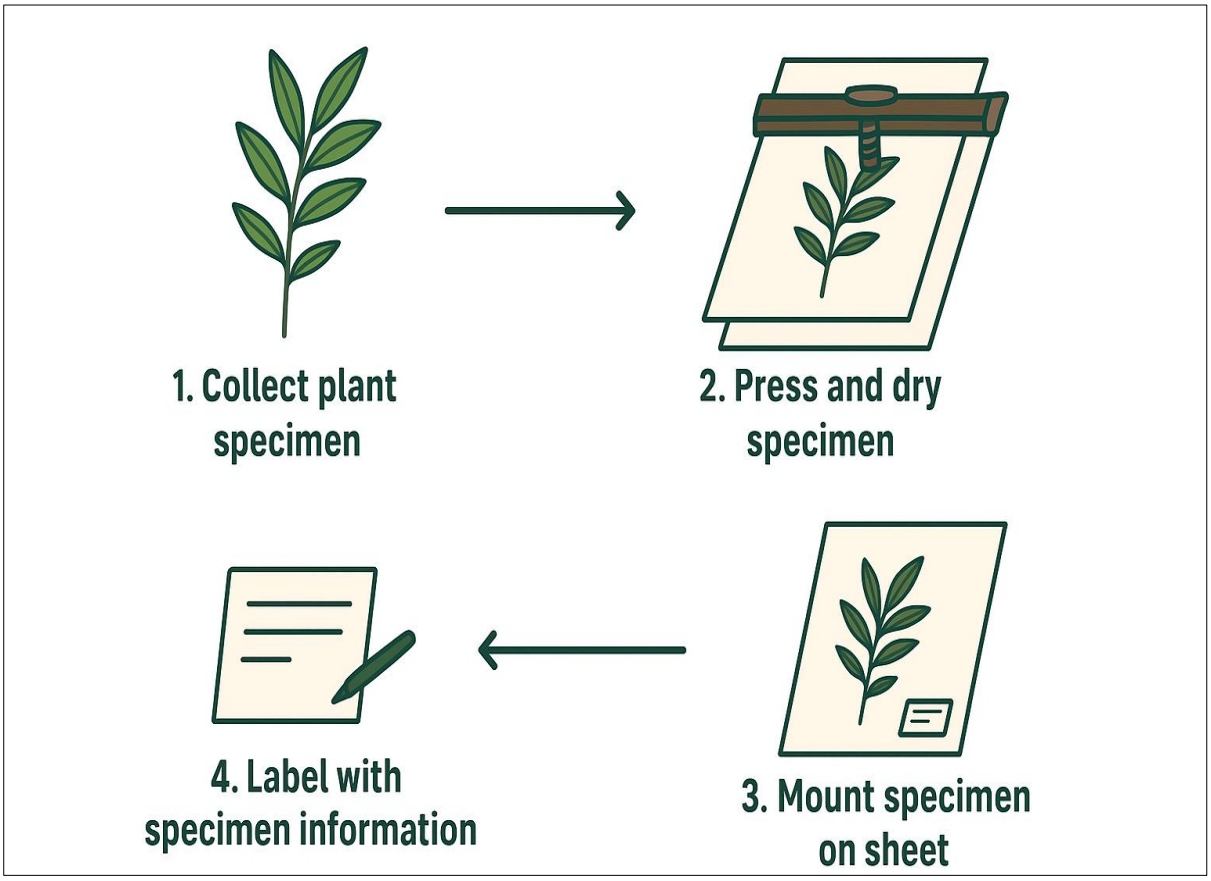

Figure 9: Procedure for preparation of an herbarium specimen sheet

Figure 10: Herbarium Specimen submitted to the Herbarium of the Botanical Survey of India, Kolkata (CAL)

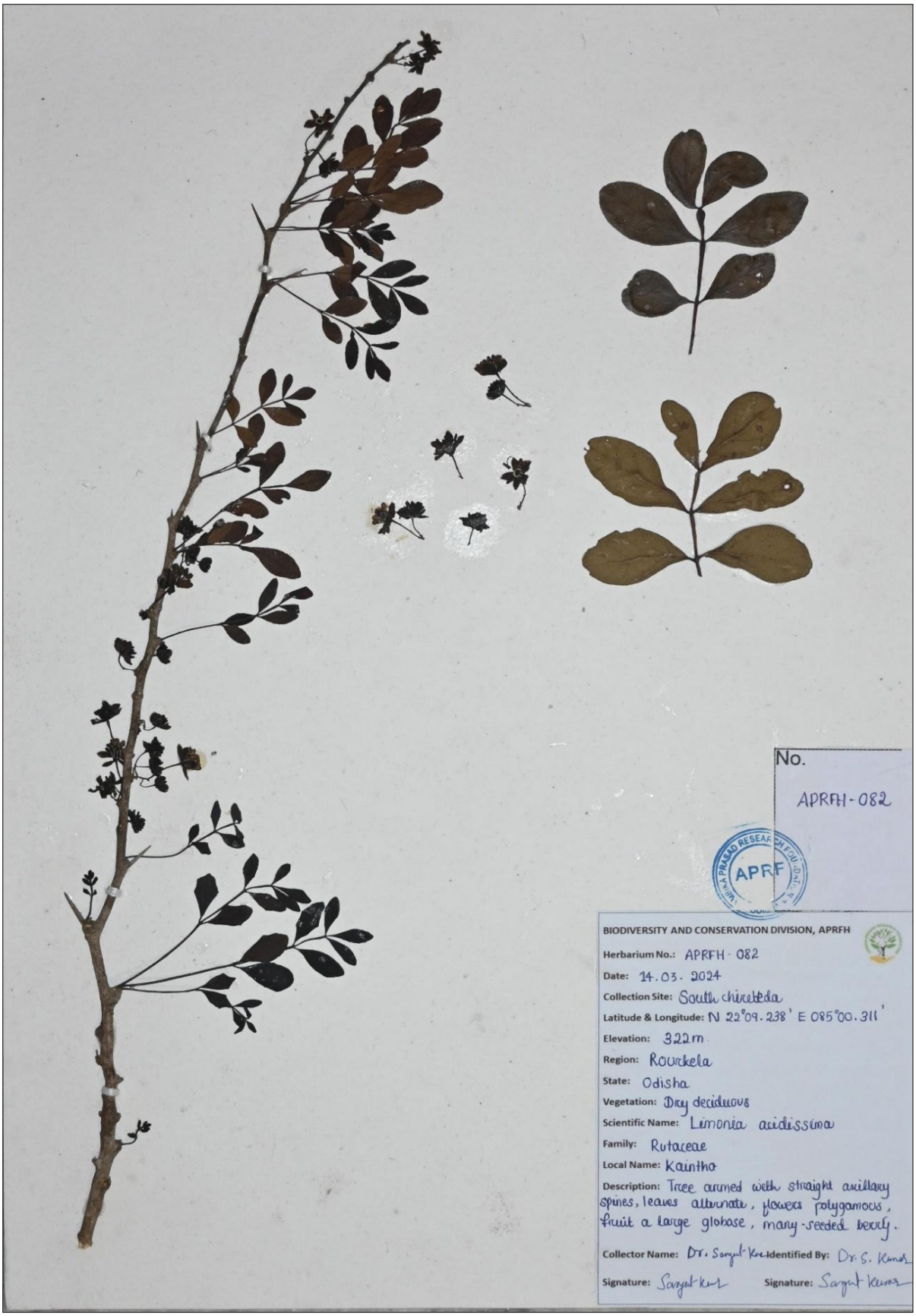

Figure 11: Herbarium specimen of the Herbarium Unit of Ambika Foundation Research Foundation (APRF), Odisha (APRFH)

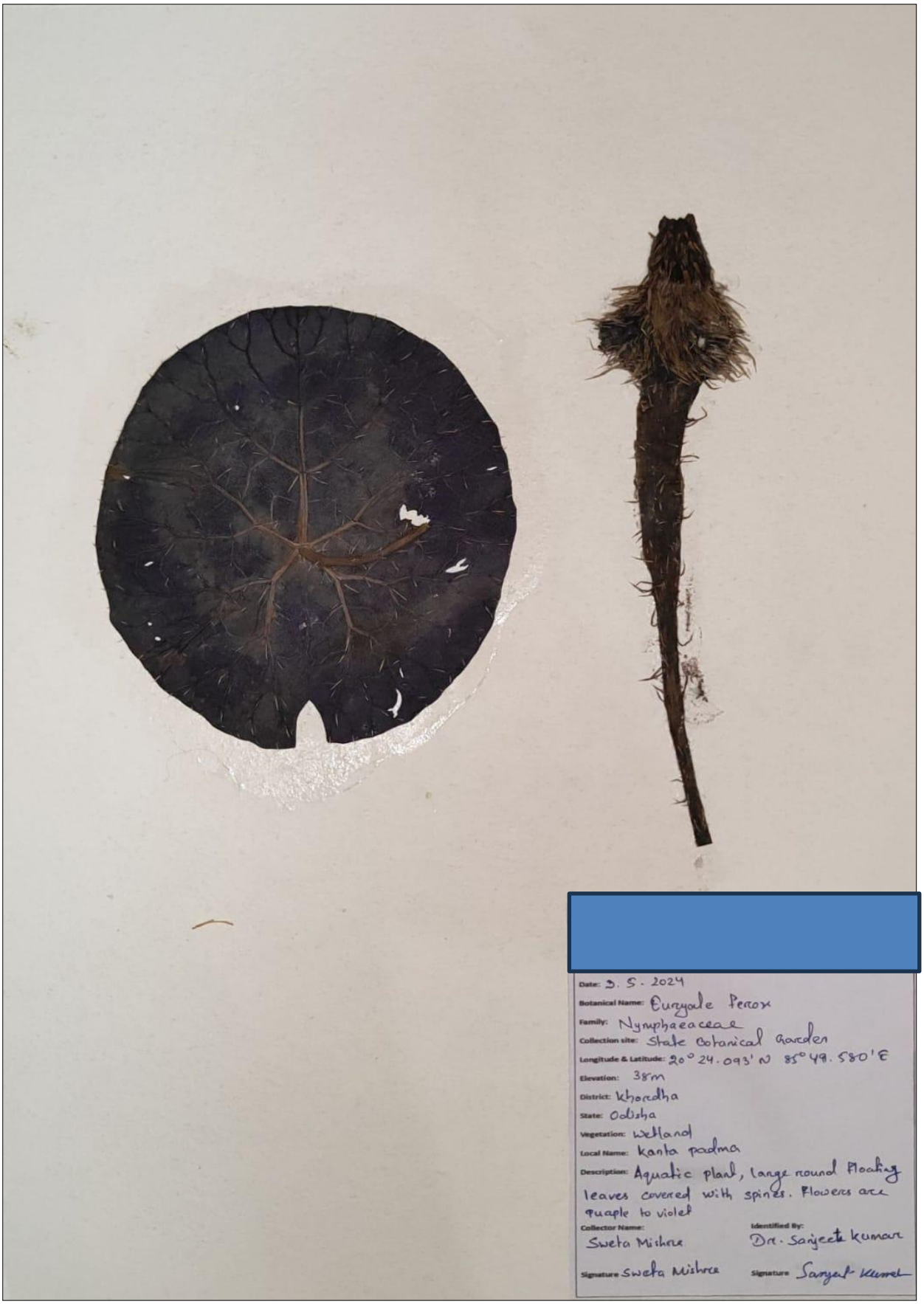

Figure 12: Herbarium specimen for the proposed Herbarium Unit

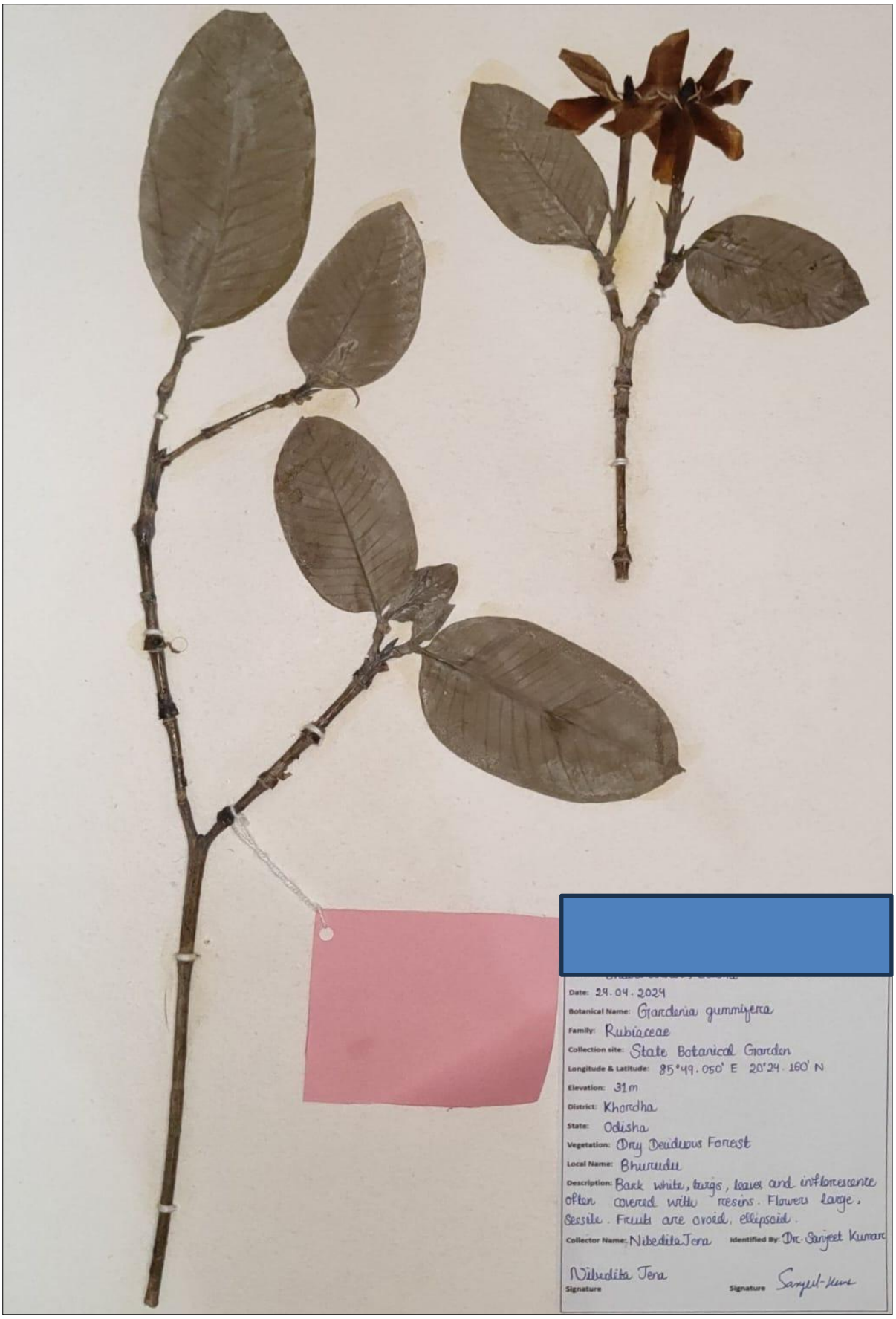

Figure 13: Herbarium specimen for the proposed Herbarium Unit

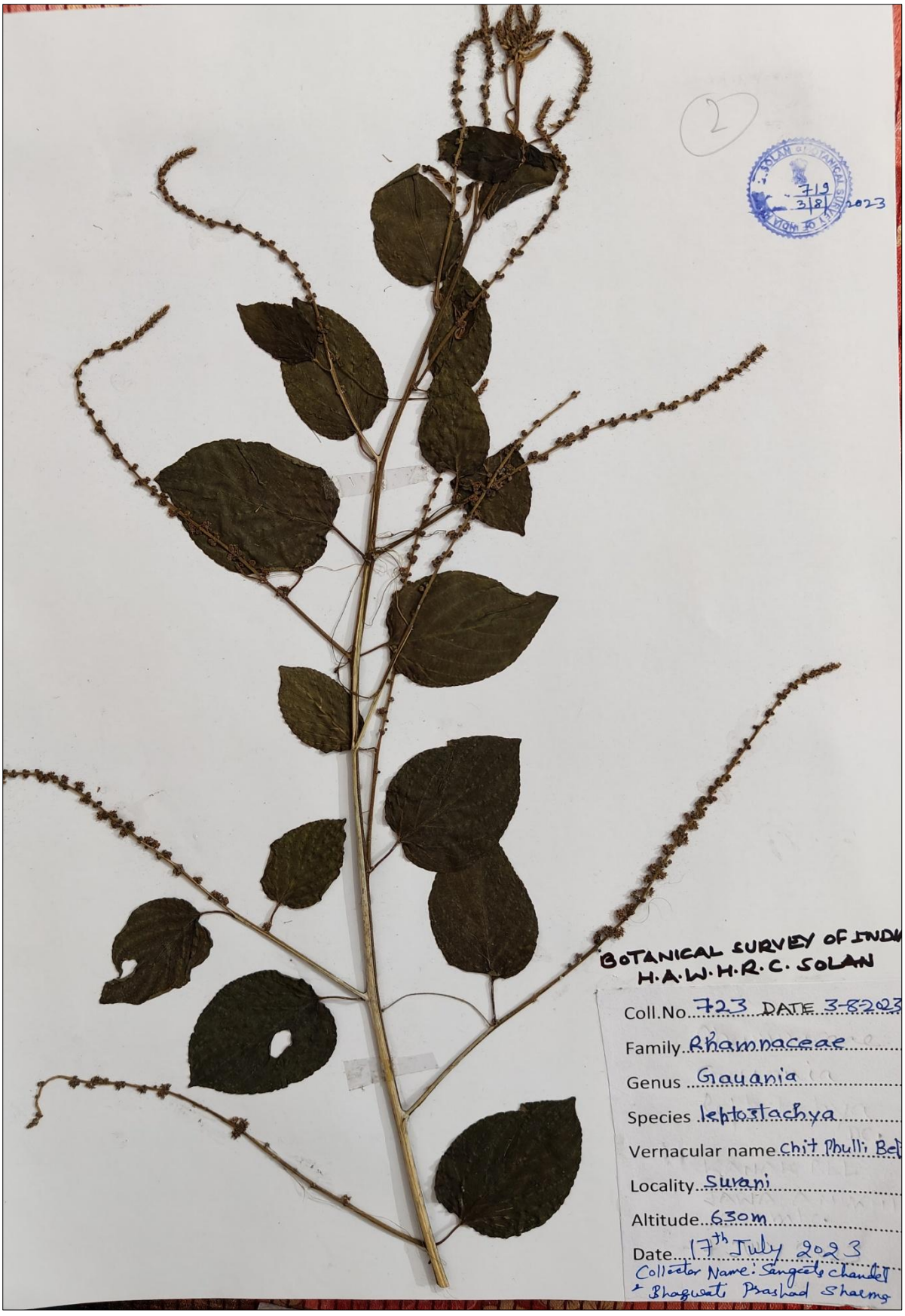

Figure 14: Herbarium specimen submitted to the Herbarium of Botanical Survey of India, HAWHRC, Solan, Himachal Pradesh, India

General instructions

i. Cleanliness should be maintained in the Herbarium Unit

ii. Any fire-related activities, like smoking, lighting spirit lamps, or candles, are strictly prohibited.

iii. The introduction of any wet substance, including wet boots, dirt, raincoats, or any items that could create humidity, is not allowed.

iv. All herbarium specimens should be poisoned or fumigated before being brought into the Herbarium Unit.

v. Naphthalene balls should be placed inside the cupboards.

vi. Cupboards should be closed immediately after retrieving the required Herbarium sheet bundle. No single sheet should be pulled out from the cupboard.

vii. When returning bundles, ensure they are placed properly, with no edges protruding or damaged.

viii. Any damaged specimen should be replaced or reported to the person in charge of the Herbarium.

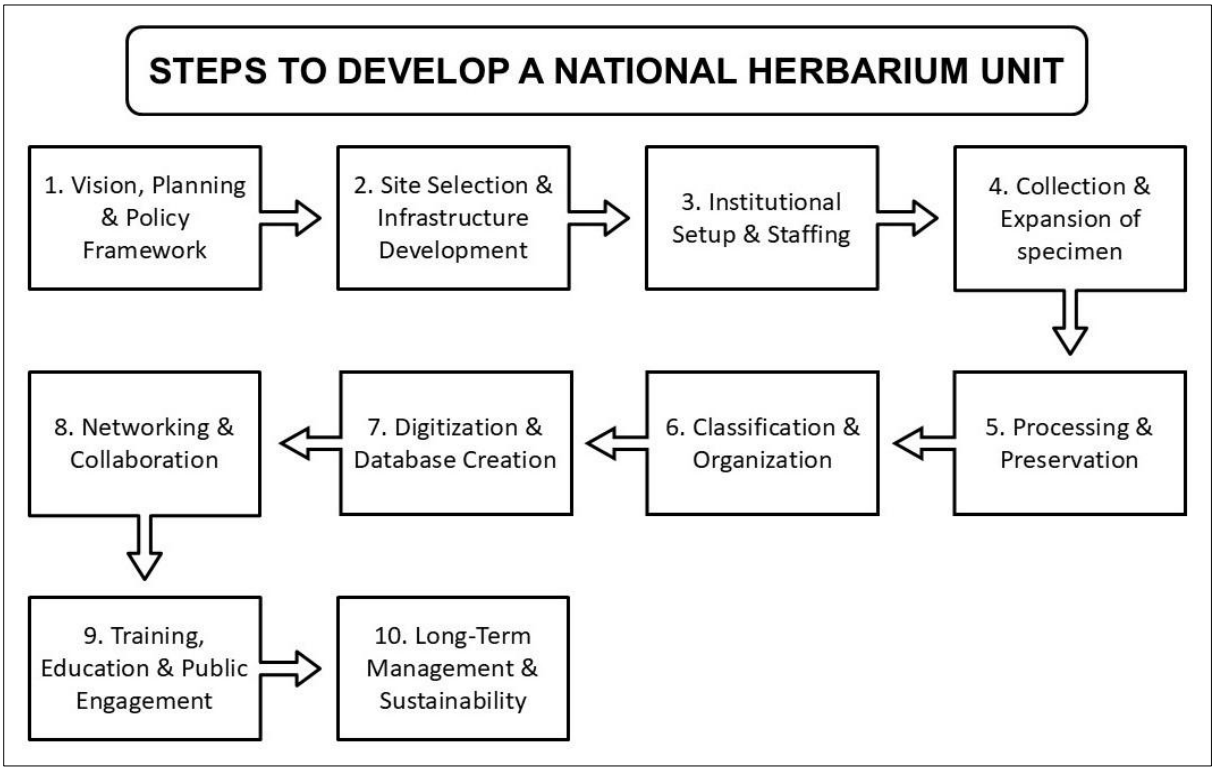

Figure 15: Proposed process for development of a national herbarium unit

Future directions

The future development of herbarium units should prioritize digitization, molecular integration, and public engagement to enhance their scientific and conservation value (Figure 15). This involves High-resolution imaging combined with the development of online databases. Digitization of the herbarium

specimens will ensure that the specimens can be accessed, studied and utilized by researchers worldwide without the need for physical handling. This approach will strengthen international collaboration by eliminating geographic and logistics barriers to specimen examination. Additionally, digitization will help preserve the integrity of fragile specimens by minimizing handling and it will enable integration with global biodiversity databases such as the Global Biodiversity Information Facility (GBIF) and JSTOR Global Plants. Overall, digitization can transform traditional collections into globally accessible resources for taxonomic verification, climate change studies, and biodiversity monitoring. Incorporation of molecular tools, especially DNA barcoding, into herbaria adds a powerful dimension to the traditional collections. DNA isolated from herbarium specimens can be used to confirm species identification, detect cryptic species and help in understanding evolutionary relationships. Molecular knowledge will ensure the participation of herbaria in phylogenetic research, population genetics and conservation biology. Additionally, incorporating automated pest management, AI-driven identification tools, and citizen-science participation will further expand their reach and educational impact. In conclusion, a well-curated herbarium is not merely a static archive but an evolving hub of biodiversity, ensuring that plant knowledge continues to support research, conservation, and sustainable utilization for generations to come.

Conclusion

An herbarium is more than just a collection of dried plants; it is a vital archive of knowledge. From careful field collection to meticulous curation, each step preserves critical information about plant diversity, ecology, and evolution. Establishing an herbarium unit enhances the educational and research missions of botanical gardens, universities, and conservation agencies, ensuring that plant biodiversity remains accessible to future generations. In educational institutions, the herbarium plays a central role in training the next generation of botanists, ecologists and conservationists. It provides students with hands-on experience in plant identification, data collection, and scientific documentation. Herbaria also support public outreach and environmental awareness. In the era of rapid biodiversity loss, herbaria serve as crucial repositories of plant information, offering insights into past and present ecosystems while guiding future conservation strategies. Preserving biodiversity through herbaria ensures that the information present in every flower, leaf, and seed is available to students, researchers, and policymakers for generations to come.

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