BloEx - Journal
Britain International of EXACT Sciences Journal
Publish: | January - May - September |
E-ISSN: 2686-1208
P-ISSN: 2686-1216
http://biarjournal.com/index.php/bioex

Bridging Ethnobotany and Ethno-Astronomy: A Systematic Review of Ethiopia's Medicinal Plant Diversity (1950–2024) and the Unexplored Potential of Celestial Harvesting Cues in Traditional Healthcare

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Abstract:

Ethiopia's rich biocultural heritage encompasses extraordinary medicinal plant diversity and sophisticated indigenous astronomical knowledge systems, yet the intersection between these domains remains critically understudied. This systematic review synthesizes ethnobotanical data from 59 studies (2010–2022) documenting 525 medicinal plant species across 113 families and 333 genera, with 44 endemic species and nine (27.3%) endangered. The review uniquely bridges ethnobotany with ethno-astronomy, introducing the emerging paradigm of ethno-astrobotany, the study of celestial influences on plant selection, harvesting, and medicinal efficacy. The Borana Oromo lunar-stellar calendar, developed around 300 BC, demonstrates remarkable predictive skill (r = 0.889 for rain onset, RMSE = 3.3 days) through observation of 12 anchor stars, while similar systems among the Amhara, Tigray, Afar, Somali, Sidama, and Konso communities guide seasonal forecasting and agricultural timing. Global evidence indicates that lunar phases significantly influence phytochemical composition, full moon harvests yield higher essential oils and bioactive compounds, as demonstrated in Withania somnifera and Oliveria decumbens. However, in Ethiopia, no systematic study has examined the relationship between ethno-astronomically determined harvesting times and pharmacological properties of medicinal plants. Urgent threats include elder attrition, modernization, climate variability, and habitat loss, accelerating biocultural erosion. This review establishes an integrated research agenda combining ethnographic documentation, phytochemical validation, longitudinal monitoring, and participatory approaches with traditional healers. Policy implications include evidence-based harvesting guidelines, conservation planning integrating celestial calendars, culturally responsive STEM education, and protection of indigenous knowledge rights. Preserving Ethiopia's interwoven biological and cultural heritage demands immediate, interdisciplinary action.

Keywords:
Ethno-astrobotany; Ethiopian medicinal plants; Borana lunar-stellar calendar; Biocultural conservation; Indigenous knowledge systems

I. Introduction

1.1 Background and Rationale

Ethiopia stands as one of Africa's most significant reservoirs of biological and cultural diversity. As part of the Horn of Africa biodiversity hotspot, the country harbors an estimated 6,000 to 7,000 flora species, of which approximately 10% possess medicinal value (Gedlu et al., 2024). This botanical wealth is matched by a profound human reliance on traditional medicine: approximately 80% of the Ethiopian population depends on traditional medicinal plants for primary healthcare (Tadege, 2023). The cultural acceptability of traditional healers, the accessibility of local pharmacopoeias, the relatively low cost of traditional medicine, and the limited reach of modern health facilities in rural areas sustain

DOI: *https://doi.org/10.5281/zenodo.22092479*

this enduring dependence. Traditional healthcare services are also sought in urban areas of Ethiopia, where allopathic services are more readily available, making a significant contribution to the country's public health care system (Tadege, 2023). Indigenous knowledge systems surrounding medicinal plants are not merely pragmatic repositories of healing practices but are deeply interwoven with Ethiopia's diverse ethnic identities, belief systems, and cosmological worldviews (Teka & Maryo, 2023).

Parallel to this ethnobotanical wealth, Ethiopia possesses a rich astronomical heritage rooted in indigenous timekeeping systems, religious traditions, and architectural alignments. Over 80 ethnic groups contribute unique interpretations of the sky, each with distinct names for stars and constellations, and many communities rely on indigenous astronomical knowledge that predates modern technologies (Goshu & Ridwan, 2025; Goshu and Ridwan, 2025a). The conceptual framework of ethno-astronomy defined as the branch of astronomy concerned with the astronomical beliefs and practices of specific cultures, dealing with the astronomical systems of living indigenous peoples (Dinsa et al., 2023; Goshu, 2025), provides a lens through which to examine how Ethiopian communities have integrated celestial observation into seasonal forecasting, pastoral mobility, ritual timing, and social organization. The Borana Oromo lunar-stellar calendar, for instance, exemplifies a sophisticated system where months are defined by new moon conjunctions with specific anchor stars such as Triangulum, Pleiades, Aldebaran, Bellatrix, Orion Saiph, and Sirius (Dinsa et al., 2023). This calendrical system, developed around 300 BC, consists of 12 lunar months of 29.5 days, totaling 354 days per year, and relies on astronomical observations of the moon in conjunction with seven particular stars or constellations (Dinsa et al., 2023).

1.2 Historical Context (1950s–Present)

The documentation of Ethiopia's medicinal plants began in earnest with early botanical explorations and the establishment of herbaria during the 1950s to 1970s. These foundational efforts, primarily undertaken by European and Ethiopian botanists, focused on taxonomic identification and the collection of voucher specimens (Tadege, 2023). The postcolonial turn from the 1980s onward marked a paradigm shift toward systematic documentation of indigenous knowledge, recognizing local communities not merely as informants but as knowledge holders whose practices are underpinned by generations of empirical observation (Teka & Maryo, 2023).

From 2010 to the present, ethnobotanical research in Ethiopia has proliferated significantly. A systematic review synthesizing data from 59 eligible studies published between 2010 and 2022 documented 525 medicinal plant species across 113 families and 333 genera (Teka & Maryo, 2023). The most represented families include Fabaceae (49 species), Asteraceae (43 species), Lamiaceae (34 species), and Euphorbiaceae (22 species) (Teka & Maryo, 2023). The highest number of species was recorded from the Southern Nations, Nationalities, and Peoples' Region (SNNPR) with 140 species, followed by Amhara (121 species) and Oromia (117 species) (Teka & Maryo, 2023). Herbs (207 species) and shrubs (156 species) were the most commonly used growth forms, while leaves (227 records) and roots (116 records) were the most frequently utilized plant parts (Teka & Maryo, 2023). Most plant materials were prepared by crushing and decoction and administered orally (Teka & Maryo, 2023). Foeniculum vulgare, Acokanthera schimperi, Allium sativum, and Carissa spinarum were the most widely used species across multiple regions (Teka & Maryo, 2023). Many medicinal plants were used to treat wounds, malaria, stomachache, and diarrhea (Teka & Maryo, 2023).

Among Ethiopia's 412 endemic plants, 44 are medicinally valuable, and nine (27.3%) of them are endangered (Ayalew et al., 2022). Pharmacological investigations have isolated 74 compounds from these endemic medicinal plants, predominantly phenolics (66.2%), with demonstrated antimalarial, antimicrobial, anticancer, anthelmintic, mosquitocidal, antidiabetic, antioxidant, and anti-inflammatory activities (Ayalew et al., 2022). A comprehensive review published in 2024 reported approximately 206 species of medicinal plants grown in Ethiopia used to treat various diseases (Gedlu et al., 2024).

II. Research Method

2.1 The Ethnobotanical Landscape of Ethiopia –; Diversity, Distribution, and Utilization Patterns

a. Species Diversity and Taxonomic Composition

Ethiopia's medicinal plant wealth represents a significant component of the country's biological heritage. A comprehensive systematic review synthesizing data from 59 eligible ethnobotanical and ethnopharmacological studies published between 2010 and 2022 documented a total of 525 medicinal plant species, distributed across 113 families and 333 genera (Feyisa et al., 2024). This substantial diversity underscores Ethiopia's status as one of Africa's most biodiverse nations and a critical reservoir of plant-based therapeutic resources (Table 1).

The taxonomic composition of Ethiopia's medicinal flora reveals clear patterns of familial dominance. Fabaceae emerges as the most represented family with 49 species, followed by Asteraceae (43 species), Lamiaceae (34 species), and Euphorbiaceae (22 species) (Feyisa et al., 2024). These four families collectively account for approximately 28% of all documented medicinal plant species, reflecting their ecological prominence and cultural significance across Ethiopian traditional medicine systems. The predominance of Fabaceae and Asteraceae is consistent with findings from regional ethnobotanical studies, where these families consistently rank among the most frequently cited for medicinal applications (Getachew et al., 2022).

At the generic level, Aloe is the most represented genus with 16 species, followed by Acacia (12 species), Euphorbia (11 species), and Solanum (11 species) (Feyisa et al., 2024). The high representation of *Aloe* species is particularly noteworthy given the genus's well-documented therapeutic applications, including wound healing, antimicrobial, and anti-inflammatory properties. The prevalence of *Acacia* and *Euphorbia* species reflects their wide ecological distribution across Ethiopia's diverse agro-ecological zones.

Several medicinal plant species are widely shared across regions, indicating cultural exchange and cross-regional therapeutic, Foeniculum vulgare is documented across five Ethiopian regions (SNNPR, Amhara, Oromia, Tigray, and Somali), representing the most geographically widespread medicinal species (Feyisa et al., 2024). Other widely distributed species include Acokanthera schimperi, Allium sativum, and Carissa spinarum, each reported from multiple regions due to shared borders, similar climatic conditions, and cross-cultural practices (Feyisa et al., 2024).

The endemic medicinal flora of Ethiopia represents a particularly valuable component of the country's biodiversity heritage. Among Ethiopia's 412 documented endemic plant species, 44 are medicinally valuable (Ayalew et al., 2022). Alarmingly, nine of these endemic medicinal plants (27.3%) are classified as endangered, highlighting the urgent need for conservation interventions. This review by Ayalew et al. (2022) represents the first comprehensive appraisal of traditional use, pharmacological properties, and phytochemistry of Ethiopian endemic medicinal plants, providing a critical foundation for conservation prioritization.

Table 1. Dominant Medicinal Plant Families and Genera in Ethiopia

Rank	Family	Number of Species	Representative Genera
1	Fabaceae	49	*Acacia*, *Crotalaria*, *Erythrina*
2	Asteraceae	43	*Vernonia*, *Echinops*, *Bidens*
3	Lamiaceae	34	*Ocimum*, *Thymus*, *Plectranthus*
4	Euphorbiaceae	22	*Euphorbia*, *Croton*, *Ricinus*
5	Rubiaceae	—	*Coffea*, *Gardenia*
6	Solanaceae	—	*Solanum*, *Datura*
Rank	Genus	Number of Species	
1	*Aloe*	16	
2	*Acacia*	12	
3	*Euphorbia*	11	
4	*Solanum*	11	
5	*Vernonia*	—	

Source: Adapted from Feyisa et al. (2024)

Figure 1 provides a hierarchical visualization of Ethiopia's medicinal flora, synthesizing data from 59 eligible ethnobotanical studies. The root node of 525 species branches into three primary taxonomic levels: 113 families, 333 genera, and the species themselves, underscoring the country's remarkable botanical richness (Feyisa et al., 2024). At the family level, Fabaceae (49 species) and Asteraceae (43 species) emerge as the most represented taxa, corroborating their dominance in African pharmacopoeias. Notably, the genera *Aloe* (16 species) and *Acacia* (12 species) are highlighted, reflecting both their ecological prevalence and therapeutic versatility. A critical distinction is drawn between endemic species (44) and widely shared species. The endemic taxa represent a unique resource with high conservation priority—alarmingly, nine (27.3%) are classified as endangered (Ayalew et al., 2022). In contrast, widely shared species demonstrate cross-regional cultural exchange and therapeutic consensus across ethnic groups.

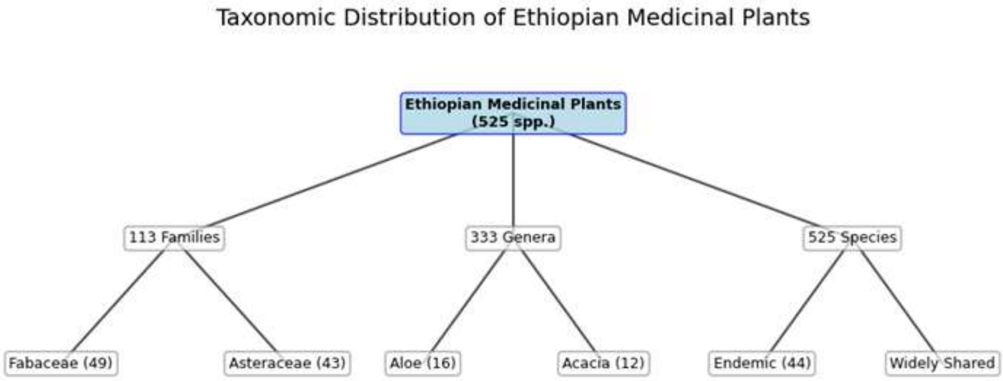


Figure 1: Taxonomic Distribution of Ethiopian Medicinal Plants *(Schematic representation of the 525 species distributed across 113 families and 333 genera) (Data compiled from Feyisa et al., 2024; Ayalew et al., 2022)*

This visualization effectively encapsulates the dual dimensions of taxonomic diversity and biogeographic status, establishing a foundational framework for subsequent pharmacological validation and biocultural conservation strategies.

2.2 Regional Distribution Patterns

The distribution of medicinal plant species across Ethiopia's regional states exhibits notable geographic variation, shaped by ecological, climatic, and cultural factors. The Southern Nations, Nationalities, and Peoples' Region (SNNPR) records the highest concentration with 140 species, followed by Amhara Region (121 species) and Oromia Region (117 species) (Feyisa et al., 2024). This regional distribution pattern aligns with the ecological diversity of these areas, which encompass Afroalpine, montane forest, woodland, and lowland vegetation zones (Table 2).

high species diversity in SNNPR can be attributed to several factors. The region's varied topography, ranging from the Rift Valley lowlands to the highlands of the Gamo Gofa and Kaffa zones, supports multiple vegetation types. Additionally, SNNPR is home to numerous ethnic groups with deep-rooted traditional medical practices, including the Konso, Sidama, and Gurage peoples; each contributing unique ethnobotanical knowledge. The Amhara and Oromia regions, being the most populous in Ethiopia, also harbor extensive traditional medicine systems that have been systematically documented through numerous ethnobotanical surveys.

Recent comprehensive studies have significantly expanded the documented medicinal plant knowledge from Ethiopia's lowland pastoral regions. A mixed-methods study of the Somali pastoralist people in eastern Ethiopia documented 213 medicinal plant species from 64 families, with Fabaceae dominating (16%). Notable species include *Tamarindus indica* (demonstrating 81.09% anti-malarial suppression) and the endemic *Halothamnus somalensis* (Woldeamanuel et al., 2026a). Similarly, an integrated ethnobotanical and ethnomedicinal study of the Afar pastoralists in northeastern Ethiopia recorded 158 medicinal plant species belonging to 52 families and 128 genera (Woldeamanuel et al., 2026b).

The Tigray Region has been the subject of multiple ethnobotanical investigations. A study in the Ganta Afeshum District (Eastern Zone) documented 173 medicinal plant species distributed across 77 families and 156 genera (Gebrehiwot et al., 2018). In the Adwa District (Central Zone), 127 medicinal plants belonging to 105 genera under 54 families were recorded, with Fabaceae and Solanaceae being the most important families (8.66% each) (Tahir et al., 2024). Herbs (55 species) were the dominant growth form, followed by shrubs (39 species), and while leaves (24.27%) and roots (14%) were the most frequently used plant parts (Tahir et al., 2024). The most important preparation methods included crushing and pounding (42.7%) followed by fumigation (11.1%), with skin application (32%) and oral administration (27%) being the primary routes. Tonsillitis had the highest informant consensus factor value (0.95), while *Cucumis ficifolius* was the most preferred plant for treating abdominal pain (Tahir et al., 2024) (table 2).

The Benishangul-Gumuz Region has also emerged as a significant repository of medicinal plant diversity. A comprehensive study in the Dibatie District (Metekel Zone) documented 170 medicinal plant species belonging to 144 genera and 65 families, used to treat 79 human and 29 livestock ailments (Anbessa et al., 2024). Fabaceae (20 species) and Asteraceae (18 species) were the dominant families, while herbs (61 species, 35.88%) and shrubs (39 species, 22.94%) were the most common growth forms (Anbessa et al., 2024). The majority (79.41%) of medicinal plants was harvested from wild sources, and oral administration (52.20%) was the predominant route. *Embelia schimperi*, *Glinus lotoides*, *Haplosciadium abyssinicum*, *Mucuna melanocarpa*, and *Phragmanthera macrosolen* demonstrated the highest fidelity level values (100%) against their corresponding ailments (Anbessa et al., 2024). In the Assosa District, 54 medicinal plants belonging to 49 genera and 33 families were identified, with Solanaceae being the most represented family (Zelalem et al., 2024). The highest fidelity level (100%) was recorded for hemorrhoids and gastric ulcers, while the highest informant consensus factor (0.96) was linked to diseases of the eye and adnexa (Zelalem et al., 2024).

The Gambella Region has been documented through studies focusing on the indigenous communities. A study in the Jikawo District recorded 81 medicinal plant species distributed across 68 genera and 41 families, with Fabaceae ranking first (10 species), followed by Euphorbiaceae and Poaceae (5 species each) (Nurie & Belude, 2023). These plants were used to treat 42 human and 18 livestock health problems, with trees (31 species) and herbs (28 species) as the dominant growth forms, and leaves (41.53%) and roots (20%) as the most frequently used parts (Nurie & Belude, 2023). Traditional medicines were mostly prepared from fresh plant materials (60.98%), with crushed preparations (32.35%) and oral administration (53.22%) predominating. A study in the Itang District documented 57 medicinal plants from 36 families and 55 genera, with Fabaceae, Euphorbiaceae, Solanaceae, and Poaceae being the most commonly used families (Dires, 2017). Roots (26.06%) and fruits (24.37%) were the most frequently used plant parts, and 13 species were specifically used for stomach ache treatment (Dires, 2017). A broader community-based study in the Gambella Region identified 81 medicinal plants for the traditional treatment of both human (25) and animal (16) diseases, with shrubs (37.03%) and trees (32.10%) as the dominant growth forms (Gambella Region Study, 2019). Oral administration accounted for 61.73% of remedies, and urine, placental retention, and milk let-down showed the highest informant consensus factor (0.96) (Gambella Region Study, 2019) (Figure 2).

Cross-regional sharing of medicinal plant knowledge occurs through trade networks, migration patterns, and cultural exchange. Species such as *Foeniculum vulgare* (five regions), *Acokanthera schimperi*, and *Carissa spinarum* are utilized across multiple regional states, reflecting both the widespread distribution of these species and the diffusion of therapeutic knowledge through cultural contact (Feyisa et al., 2024). The sharing of medicinal plants between regions varies by ailment category, with gastrointestinal and dermatological ailments showing the highest number of shared species (Feyisa et al., 2024).

Table 2: Regional Distribution of Medicinal Plant Species in Ethiopia

Regional State	Number of Species	Notable Ecological Zones	Key References
SNNPR	140	Afroalpine, Montane forest, Rift Valley	Feyisa et al. (2024)
Amhara	121	Ethiopian Highlands, Lake Tana basin	Feyisa et al. (2024)
Oromia	117	Bale Mountains, Rift Valley, lowlands	Feyisa et al. (2024)
Somali	213	Arid and semi-arid lowlands	Woldeamanuel et al. (2026a)
Afar	158	Desert, semi-desert, arid lowlands	Woldeamanuel et al. (2026b)
Tigray	173	Highlands, dry woodlands	Gebrehiwot et al. (2018)
Tigray	127	Highlands, dry woodlands	Tahir et al. (2024)
Tigray	97	Highlands, dry woodlands	Mengistu et al. (2022)

Tigray	67	Highlands, dry woodlands	Teklay et al. (2025)
Benishangul-Gumuz	170	Lowland woodlands	Anbessa et al. (2024)
Benishangul-Gumuz	54	Lowland woodlands	Zelalem et al. (2024)
Gambella	81	Lowland forests	Nurie & Belude (2023)
Gambella	57	Lowland forests	Dires (2017)
Gambella	81	Lowland forests	Gambella Region Study (2019)

Sources: Adapted from Feyisa et al. (2024); Woldeamanuel et al. (2026a, 2026b); Gebrehiwot et al. (2018); Tahir et al. (2024); Mengistu et al. (2022); Teklay et al. (2025); Anbessa et al. (2024); Zelalem et al. (2024); Nurie & Belude (2023); Dires (2017); Gambella Region Study (2019)

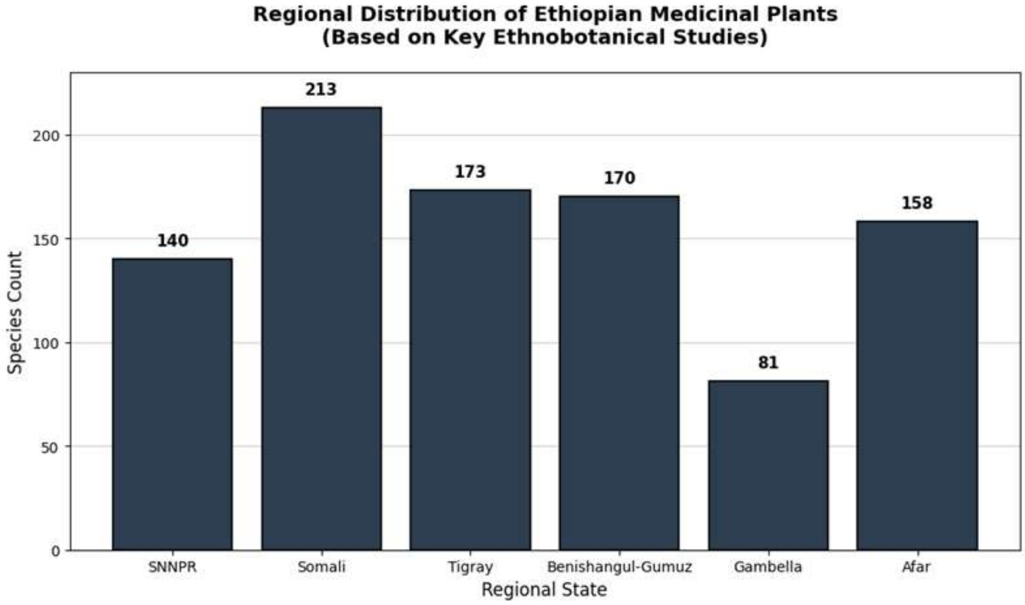


Figure 2: Regional Distribution of Ethiopian Medicinal Plants

(Data from Feyisa et al., 2024; Woldeamanuel et al., 2026a, 2026b; Gebrehiwot et al., 2018; Tahir et al., 2024; Anbessa et al., 2024; Nurie & Belude, 2023)

The cumulative evidence from these regional studies demonstrates that Ethiopia's medicinal plant diversity extends far beyond the historically well-documented highland regions. The Tigray Region alone has yielded over 460 documented medicinal plant species across multiple studies, while Benishangul-Gumuz (170 species) and Gambella (81+ species) have emerged as significant, previously understudied reservoirs of ethnobotanical knowledge. The dominance of Fabaceae across all regions, the consistent preference for leaves and herbs, and the widespread reliance on fresh preparations and oral administration reflect shared therapeutic principles that transcend ethnic and ecological boundaries. However, the varying informant consensus and fidelity level values across regions highlight both the richness of indigenous knowledge and the urgency of documentation and conservation efforts, as agricultural expansion, overgrazing, deforestation, and drought continue to threaten these invaluable plant resources and the traditional knowledge systems that sustain them.

2.3 Growth Forms and Plant Part Utilization

The growth form preference in Ethiopian traditional medicine reveals clear cultural and ecological patterns that transcend regional boundaries. Herbs are the most commonly utilized growth form, documented in 207 species, followed by shrubs (156 species) (Feyisa et al., 2024). This preference for herbs and shrubs over trees and climbers is culturally driven by several interconnected factors:

Ease of harvesting

Herbs and shrubs are more accessible than trees, requiring minimal effort for collection. Minimal ecological disturbance Harvesting herbs and shrubs typically causes less damage to plant populations compared to felling trees or extracting large roots. Year-round availability many herbaceous species are available throughout the year, particularly in areas with reliable rainfall patterns. The dominance of herbs is also closely tied to rainfall patterns, as herbaceous vegetation responds rapidly to seasonal precipitation.

Regional studies corroborate this national pattern while revealing subtle variations. In the Ganta Afeshum District of Tigray, herbs (47.4%) dominated the medicinal flora, followed by shrubs (23.1%) (Gebrehiwot et al., 2018). Similarly, in Adwa District, herbs (55 species) were the most common growth form, followed by shrubs (39 species) (Tahir et al., 2024). In Benishangul-Gumuz, herbs (61 species, 35.88%) and shrubs (39 species, 22.94%) were the dominant forms (Anbessa et al., 2024), while in Gambella, trees (31 species) and herbs (28 species) were most frequently utilized (Nurie & Belude, 2023). The Somali pastoralists predominantly utilized shrubs and trees, reflecting the arid-adapted flora of lowland regions (Woldeamanuel et al., 2026a), whereas the Afar pastoralists showed a preference for shrubs, herbs, and trees, adapting to the harsh desert environment (Woldeamanuel et al., 2026b).

In contrast, a systematic review of medicinal plants used for tuberculosis treatment in Ethiopia reported shrubs (35.7%) and trees (29.6%) as dominant growth forms (Getachew et al., 2022), suggesting that growth form preference may vary by ailment category. This variation reflects the specific therapeutic requirements and the ecological availability of plants with anti-tubercular properties, which are often found in woody perennial species (Table 3).

Regarding plant part utilization, leaves are the most frequently used plant part, documented in 227 records, followed by roots (116 records) and seeds (Feyisa et al., 2024). The predominance of leaves can be explained through several interconnected rationales:
For tuberculosis treatment specifically, roots (31.6%) and leaves (28.6%) were the most frequently used plant parts (Getachew et al., 2022), indicating that root-based remedies may be particularly valued for chronic or severe conditions. This preference for roots aligns with the deeper concentration of bioactive compounds in root tissues, which may be more effective against persistent infections like tuberculosis.

Table 3: Growth Forms and Plant Part Utilization in Ethiopian Traditional Medicine

Growth Form	Number of Species	Regional Variation
Herbs	207	Dominant in Tigray (47.4%), Adwa (55 spp.), Benishangul-Gumuz (35.88%)
Shrubs	156	Dominant in Somali region, Afar, tuberculosis studies (35.7%)

Trees	—	Significant in Gambella (31 spp.), Somali pastoralists (21.6%)
Climbers	—	Less represented across all regions

Sources: Adapted from Feyisa et al. (2024); Getachew et al. (2022); Gebrehiwot et al. (2018); Tahir et al. (2024); Anbessa et al. (2024); Nurie & Belude (2023); Woldeamanuel et al. (2026a, 2026b)

Table 4: Plant part utilization patterns across Ethiopian traditional medicine systems, showing regional variations in harvesting preferences and preparation methods

Plant Part	Number of Records	Common Preparations	Regional Preference
Leaves	227	Crushing, decoction, powder	Dominant across all regions (24–41%)
Roots	116	Decoction, powder, chewing	High in Tigray (14–22%), TB studies (31.6%)
Bark	—	Decoction, powder	Significant in Somali (25%)
Seeds	—	Powder, chewing	Used for specific conditions
Flowers	—	Infusion, decoction	Less frequently used

Table 4 presents a comprehensive synthesis of plant part utilization patterns across Ethiopian traditional medicine systems. Leaves emerge as the most frequently used plant part (227 records), dominating across all regions with a utilization range of 24–41% (Feyisa et al., 2024; Gebrehiwot et al., 2018; Tahir et al., 2024; Anbessa et al., 2024; Nurie & Belude, 2023; Woldeamanuel et al., 2026a, 2026b). This consistent preference reflects the sustainability of leaf harvesting, which generally does not threaten plant survival, and their concentrated bioactive compounds (Ayalew et al., 2022). Roots (116 records) show significant regional variation, highly utilized in Tigray (14–22%) and tuberculosis studies (31.6%), indicating their therapeutic value for chronic conditions (Getachew et al., 2022). Notably, bark constitutes 25% of plant part utilization among Somali pastoralists, reflecting adaptation to arid-adapted woody flora (Woldeamanuel et al., 2026a). The differential utilization of plant parts across regions demonstrates indigenous communities' sophisticated understanding of both therapeutic efficacy and ecological sustainability, while the high reliance on roots raises conservation concerns requiring immediate attention.

Figure 3 presents the proportional utilization of different plant parts in Ethiopian traditional medicine, based on data from Feyisa et al. (2024). Leaves constitute the most frequently used plant part, accounting for 58.8% (227 records) of all documented plant part records, followed by roots at 30.1% (116 records), and seeds at 11.1% (43 records). This overwhelming preference for leaves reflects their accessibility, year-round availability, and concentration of secondary metabolites—including alkaloids, flavonoids, and phenolics—that serve as plant defense mechanisms against herbivores and pathogens (Ayalew et al., 2022). The dominance of leaves also aligns with sustainable harvesting practices, as leaf collection typically does not threaten plant survival, unlike root harvesting which can be fatal to plants (Feyisa et al., 2024).

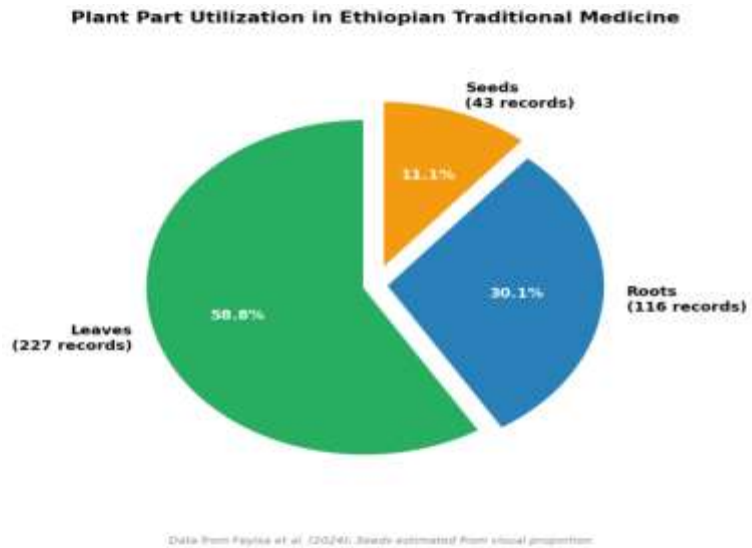


Figure 3: Proportional use of plant parts in Ethiopian traditional medicine, showing leaf dominance (58.8%) across all regions (Feyisa et al., 2024) (Data from Feyisa et al., 2024)

The substantial utilization of roots (30.1%) is particularly noteworthy. Regionally, roots are highly valued in Tigray (14–22%) and tuberculosis treatment studies (31.6%), indicating their therapeutic importance for chronic and severe conditions where deeper-acting bioactive compounds are required (Getachew et al., 2022). Among Somali pastoralists, bark (25%) and roots (17%) are also significant, reflecting adaptation to arid-adapted woody flora (Woldeamanuel et al., 2026a). Seeds (11.1%) represent a smaller but consistent component, primarily used in powdered form for specific conditions. This differential utilization demonstrates indigenous communities' sophisticated understanding of both therapeutic efficacy and ecological sustainability. However, the considerable reliance on roots raises conservation concerns, particularly for slow-growing species with limited populations, underscoring the need for sustainable harvesting guidelines and conservation strategies (Ayalew et al., 2022).

The consistency of growth form and plant part preferences across Ethiopia's diverse ecological zones reflects shared therapeutic principles that transcend ethnic and environmental boundaries. Herbs and leaves dominate due to their accessibility, sustainability, and perceived potency, while roots and bark are selectively harvested for chronic conditions. This balanced approach to plant part utilization demonstrates a sophisticated understanding of both therapeutic efficacy and ecological sustainability. The preferential use of leaves reduces pressure on plant populations, contributing to the resilience of medicinal plant resources. However, the high reliance on roots (14–31.6% across regions) raises conservation concerns, as root harvesting can be fatal to plants. This underscores the urgent need for sustainable harvesting guidelines and conservation strategies to protect Ethiopia's invaluable medicinal plant heritage.

III. Result and Discussion

3.1 Ethno-Astronomical Knowledge Systems in Ethiopia – Celestial Calendars, Seasonal Forecasting, and Temporal Practices

a. The Rich Heritage of Ethiopian Ethno-Astronomy

Ethiopia possesses one of Africa's most profound and enduring astronomical heritages, rooted in indigenous timekeeping systems, religious traditions, and architectural alignments that predate modern technologies (Goshu & Ridwan, 2025) (Table 5). Ancient Ethiopian civilizations, including the Axumite Kingdom and the Borena Oromo, developed sophisticated methods to observe celestial bodies for agricultural, ritualistic, and governance purposes (Goshu & Ridwan, 2025). The pre-Christian Axumite civilization erected pillars and monuments aligned with solstices and lunar cycles for time and season marking, while Lalibela's rock-hewn churches show possible astronomical alignments, reinforcing the integration of astronomy into Ethiopian religious practices (Goshu & Ridwan, 2025).

Ethiopia's more than 80 ethnic groups contribute unique interpretations of the sky, each with distinct names for stars and constellations, offering rich perspectives on universal questions (Goshu & Ridwan, 2025). Many communities rely on indigenous astronomical knowledge that predates modern technologies, with historical connections showing parallels with Egyptian, Mesopotamian, and Greco-Roman astronomical traditions (Goshu & Ridwan, 2025). The Ethiopian calendar itself demonstrates ancient connections to astronomy, with Ethiopians recognized among the first peoples to develop the wisdom of astrology as the main instrument for calendar production (Goshu & Ridwan, 2025).

The Borana Oromo lunar-stellar calendar and similar systems among the Amhara, Tigray, Afar, Somali, Konso, and other groups integrate celestial observation with seasonal forecasting, pastoral mobility, ritual timing, and social organization through Gadaa cycles (Goshu & Ridwan, 2025; Dinsa et al., 2023). These knowledge systems are scientifically valid, adaptive, and demonstrate proven forecasting utility, yet they face accelerating threats from elder attrition, urbanization, modernization, and climate variability (Goshu & Ridwan, 2025). Oral transmission dominates at 64.3%, with narratives emphasizing time, weather, and navigation (Goshu & Ridwan, 2025).

Table 5: Overview of Ethiopian Ethno-Astronomical Knowledge Systems

Ethnic Group	Knowledge System	Primary Celestial Bodies	Key Functions
Borana Oromo	Lunar-stellar calendar	12 anchor stars, Moon	Seasonal forecasting, Gadaa cycles, pastoral mobility
Amhara/Tigray	Bahire Hasab (Abushakir)	Sun, Moon, stars	Calendar computation, religious timing
Sidama	Fiche Chambalala cosmic calendar	Pleiades (Kore), Buusa constellation, Moon	New Year determination, agricultural timing
Afar	Star-based seasonal indicators	Stars, Moon	Weather prediction, pastoral planning
Somali	Star-moon alignment system	12 normal stars, Moon	Rainfall forecasting, livelihood decisions

Konso	Similar to Borana system	Stars, Moon	Agricultural and ritual timing

Sources: Adapted from Goshu & Ridwan (2025); Dinsa et al. (2023); Tediso et al. (2025)

Figure 4 illustrates the geographic distribution and diversity of ethno-astronomical knowledge systems across Ethiopia. The spatial representation identifies distinct knowledge traditions associated with Tigray and Amhara through the Bahire Hasab calendar, Afar through star-based environmental indicators, and Oromia through the Borana calendar (Goshu, 2026). Sidama's Fiche Chambalala and astronomical traditions documented among communities in the former SNNPR further demonstrate the integration of celestial observations into cultural and seasonal practices (Figure 4). In eastern Ethiopia, Somali communities are represented through knowledge systems involving star-moon alignment. Collectively, the figure demonstrates that ethno-astronomical knowledge is geographically widespread and culturally differentiated, reflecting locally developed relationships between celestial observations, seasonal cycles, agricultural activities, pastoral practices, and community organization. The distribution therefore highlights astronomy as an important component of Ethiopia's diverse indigenous knowledge systems.

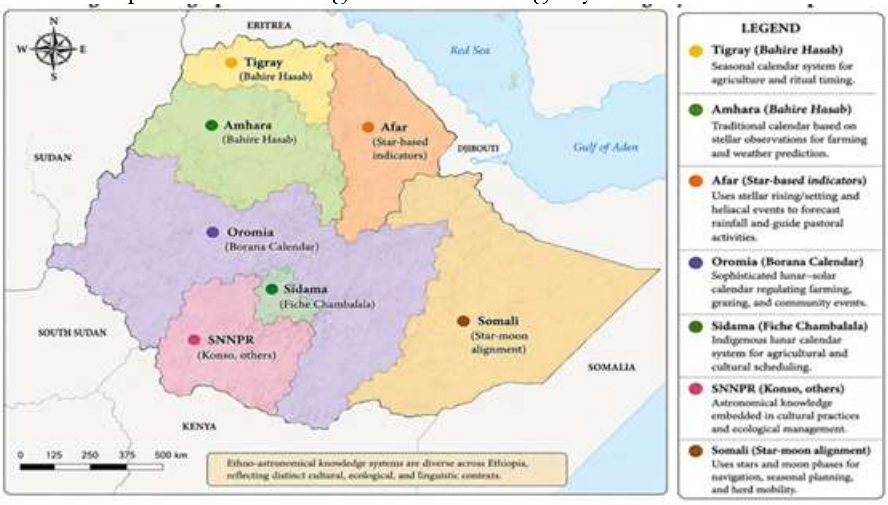


Figure 4: Geographic distribution of ethno-astronomical knowledge systems across Ethiopian regions, highlighting diverse celestial calendars, seasonal indicators, and culturally embedded astronomical practices. *(Data from Goshu & Ridwan, 2025; Dinsa et al., 2023)*

b. The Borana Oromo Lunar-Stellar Calendar

The Borana Oromo calendar represents one of Africa's most sophisticated indigenous calendrical systems, developed around 300 BC and consisting of 12 lunar months of 29.5 days, totaling 354 days in a year (Bassi, 1988; Goshu & Ridwan, 2025; Goshu, 2026). Unlike the Gregorian calendar's fixed solar cycle, the Borana system tracks the rising of stars such as Aldebaran and the Pleiades to mark seasons, regulating agricultural and ceremonial activities through specific star and moon cycle observations (Goshu & Ridwan, 2025).

The calendar operates as a lunar-stellar system where months are named after stars and lunar phases: Bittottessa (Triangulum), Camsa (Pleiades), and others. Each month consists of 29.5 days, and the calendar has no weeks but rather names for each day of the month (Goshu & Ridwan, 2025). The Borana Oromo community has been reading and defining 12 distinct normal stars that are naturally aligned in temporal predetermined patterns with the Moon in the process of forecasting the magnitude of the upcoming Hagayyaa rainfall (September to October) and Ganna rainfall season (March to May) since time immemorial (Dinsa et al., 2023).

These 12 stars are locally called Lammii, Busaan, Sorsa, Algajim, Arba Gaddu, Walla, Lammii Basaa, Torbaan, Wajjinoo, Angofii, Mataan Gohii and Korma Maddo, with names derived in respect to the size, numbers, and group formation patterns of the stars (Dinsa et al., 2023). The stars are categorized into Ganna (March to May rainfall season) and Hagayya (September to November) rainfall indicating stars (Dinsa et al., 2023) (Table 6). The calendar demonstrates remarkable predictive skill: studies have validated its forecasting accuracy with a correlation coefficient of r = 0.889 for rain onset and a root mean square error of 3.3 days (Goshu & Ridwan, 2025; Dinsa et al., 2023). When nature-driven star-moon alignments deviate from their predetermined dates, it results in severe prolonged drought and rainfall anomalies, as observed when the Lammi star's alignment with the moon deviated from its predetermined day of November 9th to November 10th in 2020 and 2021, leading the local community to attribute the severe drought in the Horn of Africa region in 2021/2022 to these flaws in star-moon alignments (Dinsa et al., 2023).

The calendar is deeply integrated into Gadaa cycles, the traditional Oromo system of governance and social organization, with astronomical observations conducted by local experts called Ayyantus (specifically Warra Abba Odo) who serve as timekeepers and astrologists (Goshu & Ridwan, 2025; Dinsa et al., 2023). The calendar's integration extends to seasonal forecasting, pastoral mobility, ritual timing, and livelihood decision-making, demonstrating that indigenous astronomical knowledge remains the driver of livelihood decisions among Borana Oromo pastoralists (Dinsa et al., 2023).

Table 6: Borana Oromo 12 Anchor Stars and Their Rainfall Associations

Star Name (Local)	Rainfall Season	Function
Lammii	Ganna (March–May)	Ganna rainfall indicating star
Busaan	Ganna (March–May)	Ganna rainfall indicating star
Sorsa	Ganna (March–May)	Ganna rainfall indicating star
Algajim	Ganna (March–May)	Ganna rainfall indicating star
Arba Gaddu	Ganna (March–May)	Ganna rainfall indicating star
Walla	Ganna (March–May)	Ganna rainfall indicating star
Lammii Basaa	Ganna (March–May)	Ganna rainfall indicating star
Torbaan	Hagayya (Sept–Nov)	Hagayya rainfall indicating star
Wajjinoo	Hagayya (Sept–Nov)	Hagayya rainfall indicating star
Angofii	Hagayya (Sept–Nov)	Hagayya rainfall indicating star
Mataan Gohii	Hagayya (Sept–Nov)	Hagayya rainfall indicating star
Korma Maddo	Hagayya (Sept–Nov)	Hagayya rainfall indicating star

Source: Adapted from Dinsa et al. (2023)

Figure 5 presents a structural diagram of the Borana Oromo lunar-stellar calendar, one of Africa's most sophisticated indigenous calendrical systems, developed around 300 BC (Bassi, 1988; Goshu & Ridwan, 2025). The calendar operates on a lunar-stellar framework consisting of 12 lunar months of 29.5 days each, totaling 354 days per year (Goshu & Ridwan, 2025). Unlike the Gregorian calendar's fixed solar cycle, the Borana system tracks the rising of 12 anchor stars, including Lammii, Busaan, Sorsa, and others to mark seasons, regulating agricultural and ceremonial activities through specific star and moon cycle observations (Goshu & Ridwan, 2025; Dinsa et al., 2023).

Each month has no weeks; rather, every day possesses a specific name within a 27-day cyclic system corresponding exactly to real astronomical configurations (Goshu & Ridwan, 2025). An intercalary month is added implicitly to maintain seasonal alignment through star-moon alignments that determine seasons (Dinsa et al., 2023). The calendar's remarkable predictive skill has been scientifically validated: studies demonstrate a correlation coefficient of r = 0.889 for rain onset and a root mean square error of 3.3 days (Goshu & Ridwan, 2025; Dinsa et al., 2023). This quantitative validation confirms that Ethiopian Indigenous Astronomical Knowledge represents a scientifically valid, adaptive knowledge system with proven forecasting utility and significant practical value for livelihood decision-making (Goshu & Ridwan, 2025).

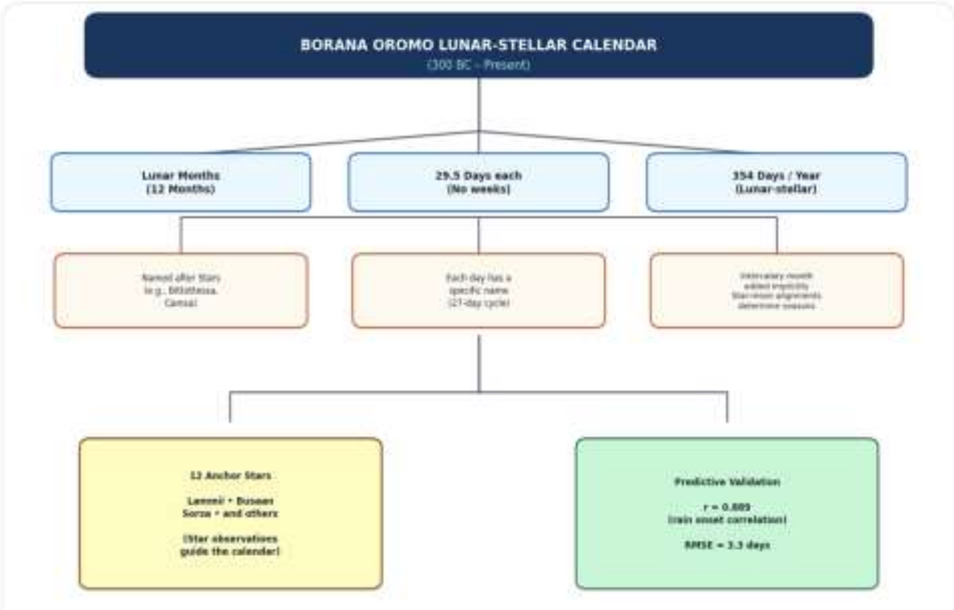


Figure 5: Structural diagram of the Borana Oromo lunar-stellar calendar showing its 12-month framework, 27-day naming cycle, and predictive validation metrics (Goshu & Ridwan, 2025). (Lammii, Busaan, r = 0.889 (rain onset), Sorsa, etc.), RMSE = 3.3 days *(Data from Bassi, 1988; Goshu & Ridwan, 2025; Dinsa et al., 2023)*

c. Other Ethno-Astronomical Systems Across Ethnic Groups

The Bahire Hasab (or Abushakir) represents a sophisticated corpus of Ge'ez manuscripts that conveys traditional knowledge pertaining to the calendar, chronology, astronomy, cosmology, astrology, meteorology, divination, and many more aspects (Goshu & Ridwan, 2025; Degue & Goshu, 2024). The term "Bahire Hasab" suggests that the manuscript contains "thoughts" and "calculations" as deep and vast as an ocean, serving as a repository for a variety of fields such as philosophy, astronomy, mathematics, history, law, and the genealogy of royal families (Degue & Goshu, 2024).

The manuscript provides a comprehensive description of the movement of the stars, sun, and moon, and calculations based on the apparent movement of the sun and the moon (Degue & Goshu, 2024). It establishes an intriguing link between the four evangelists (Matthew, Luke, John, and Mark) and the four seasons of Ethiopia (summer, autumn, winter, and spring), and presents a description of the absolute and relative measurements of time units crucial to determine days, weeks, months, and years (Degue & Goshu, 2024).

The Bahire Hasab calendar system is based on seven cycles: Cycle of Day (7 days in a week, 30 days in a month), Cycle of the Moon (29 days in a month based on lunar cycle), Cycle of the Sun (30 equal days in a month), Cycle of the Year (365 days, 6 hours, 15 minutes, and 46 seconds based on solar cycle), and additional cycles for weeks, months, and years (Degue & Goshu, 2024). The concept of "Kentros" in the Bahire Hasab manuscript is used to describe the division of time; specifically an hour into 30 parts or a day into 360 parts (Degue & Goshu, 2024). Despite its significance, these computations remain largely inaccessible, preserved in Ge'ez manuscripts and orally by ecclesiastical scholars (Alemiyan) (Goshu & Ridwan, 2025).

d. Afar, Somali, Konso, and Other Groups

The Afar and Somali pastoralists maintain similar systems integrating celestial observation with seasonal and ritual timing. Among the Somali pastoralists of eastern Ethiopia, indigenous astronomical knowledge are used for seasonal weather forecasting through observable physical and temporal patterns of astronomic objects (Dinsa et al., 2023). The Borana Oromo system has influenced neighboring communities, with the Konso people utilizing similar calendrical systems (Goshu & Ridwan, 2025) (Table 7). The Gujii pastoralists in southern Ethiopia also employ a system of seven constellation stars, with Lamii (binary stars) serving as the starting point for weather forecasting (Goshu & Ridwan, 2025).

Table 7: Ethno-Astronomical Knowledge Systems across Ethiopian Ethnic Groups

Ethnic Group	Knowledge System	Celestial Basis	Primary Function	Key Practitioners
Borana Oromo	Lunar-stellar calendar	12 anchor stars, Moon	Seasonal forecasting, Gadaa cycles	Ayyantus (Warra Abba Odo)
Amhara	Bahire Hasab (Abushakir)	Sun, Moon, stars	Calendar computation	Ecclesiastical scholars (Alemiyan)
Tigray	Bahire Hasab (Abushakir)	Sun, Moon, stars	Calendar computation	Ecclesiastical scholars (Alemiyan)
Sidama	Fiche Chambalala	Pleiades (Kore), Buusa, Moon	New Year, agricultural timing	Ayyantus (astrologists)
Afar	Star-based indicators	Stars, Moon	Weather prediction	Community elders
Somali	Star-moon alignment	12 normal stars, Moon	Rainfall forecasting	Community elders
Konso	Similar to Borana	Stars, Moon	Agricultural timing	Community elders
Gujii	Seven constellation stars	Lamii (binary stars)	Weather forecasting	Community elders

Sources: Adapted from Goshu & Ridwan (2025); Dinsa et al. (2023); Tediso et al. (2025); Degue & Goshu (2024)

e. Lunar Phases and Temporal Patterns in Indigenous Practice

Ethiopian indigenous communities have developed detailed documentation of lunar cycles, distinguishing between light/bright moon nights (days 1–15) and dark moon nights (days 16–30) (Dinsa et al., 2023). The Borana Oromo have abstractly created an astronomic-based sequential list of 27 traditional temporal patterns of the moon, which are reconfigured and varied across the 12 moon-months of the year (Dinsa et al., 2023).

Belief systems link moon emergence dates to seasonal outcomes. For example, when the September moon emerges on Gardaduma, it signals drought risk, enabling communities to prepare for potential food and water shortages (Dinsa et al., 2023) (Table 8). Traditional farming calendars reference moon appearance and days for farming practices and collecting plant materials, with specific days considered optimal for planting, harvesting, and medicinal plant collection (Dinsa et al., 2023).

The concept of Luwoo, full dark nights without moon signs, serves as temporal markers, providing reference points for community activities and decision-making (Dinsa et al., 2023). These lunar phase observations are integrated with stellar observations to create comprehensive temporal frameworks that guide livelihood decisions, agricultural practices, and ritual activities throughout the year.

Table 8: Lunar Phases and Temporal Patterns in Indigenous Practice

Lunar Phase	Days	Cultural Significance	Associated Activities
Light/Bright Moon	1–15	Favorable for activities	Planting, harvesting, ceremonies
Dark Moon	16–30	Less favorable	Restricted activities
Gardaduma	September emergence	Drought risk indicator	Preparation for food/water shortages
Luwoo	Full dark nights	Temporal markers	Community reference points

Source: Adapted from Dinsa et al. (2023)

Figure 6 presents a hierarchical visualization of the lunar cycle and its associated temporal patterns in Ethiopian indigenous practice. The 29.5-day lunar cycle branches into three distinct phases: Days 1–15 (Light/Bright Moon) , Days 16–30 (Dark Moon) , and Luwoo (Full Dark) , representing nights without moon visibility (Dinsa et al., 2023). The Light/Bright Moon phase is culturally associated with favorable activities, including planting, harvesting, and ceremonies, while the Dark Moon phase is considered less favorable for such activities (Dinsa et al., 2023). The Luwoo phase serves as temporal markers, providing reference points for community decision-making (Dinsa et al., 2023).

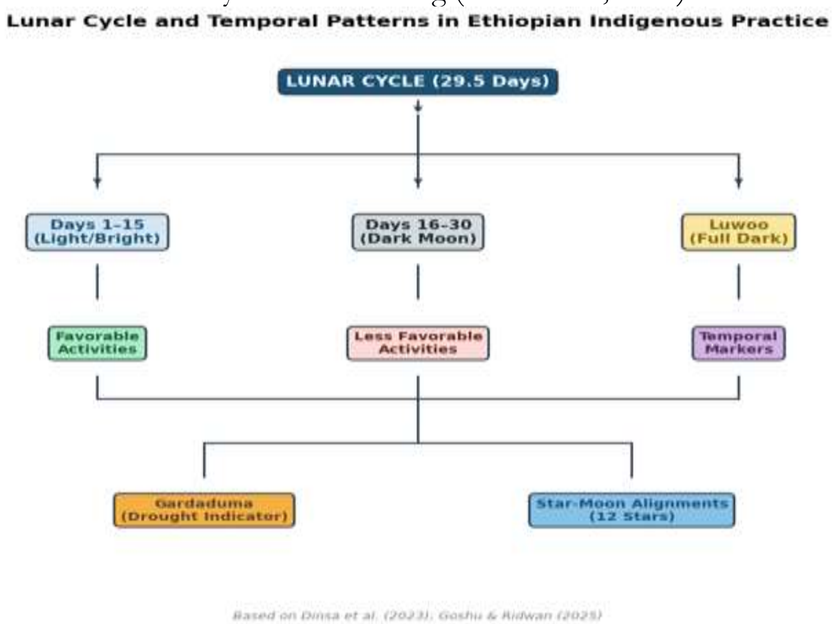


Figure 6: Hierarchical structure of the lunar cycle and temporal patterns in Ethiopian indigenous practice, showing phase-based activities and predictive indicators (Dinsa et al., 2023) *(Data from Dinsa et al., 2023)*

The framework culminates in two practical applications: Gardaduma , a drought indicator triggered when the September moon emerges on this pattern, signaling potential food and water shortages (Dinsa et al., 2023), and Star-Moon Alignments incorporating 12 anchor stars (Lammii, Busaan, Sorsa, and others) that regulate seasonal forecasting and agricultural timing (Dinsa et al., 2023; Goshu & Ridwan, 2025). This hierarchical structure demonstrates the sophisticated integration of celestial observation with livelihood decisions, ritual timing, and pastoral mobility (Dinsa et al., 2023). The predictive skill of these lunar-temporal frameworks, validated with r = 0.889 for rain onset, confirms the scientific validity of Ethiopian Indigenous Astronomical Knowledge as an adaptive system with proven forecasting utility (Goshu & Ridwan, 2025).

3.2 The Conceptual and Methodological Framework of Ethno-Astronomy

Ethno-astronomy occupies a distinct position within the broader field of cultural astronomy, requiring clear conceptual distinctions. Cultural astronomy encompasses the study of astronomical beliefs and practices across all cultures and time periods, while archaeo-astronomy focuses on the astronomical knowledge and practices of ancient civilizations as revealed through archaeological evidence (Goshu & Ridwan, 2025). Ethno-astronomy is specifically defined as the branch concerned with the astronomical beliefs and practices of living indigenous peoples—the astronomical systems of contemporary cultures (Goshu & Ridwan, 2025). Ethno-meteorology examines indigenous knowledge of weather and climate phenomena, often closely intertwined with ethno-astronomical observations (Goshu & Ridwan, 2025).

Indigenous knowledge systems operate through a framework of holism, interconnecting the self to animate and inanimate realms, physical, emotional, cultural/social, and intellectual dimensions (Goshu & Ridwan, 2025) (Table 9). This holistic worldview means that astronomical knowledge cannot be separated from its cultural, social, and ecological contexts. The Borana Oromo, for example, integrate celestial observation with seasonal forecasting, pastoral mobility, ritual timing, and social organization through Gadaa cycles, demonstrating the seamless integration of astronomy with all aspects of community life (Goshu & Ridwan, 2025).

Knowledge transmission is primarily oral (64.3%) , with narratives emphasizing time, weather, and navigation (Goshu & Ridwan, 2025). Elders and traditional experts serve as the primary custodians of ethno-astronomical knowledge, with transmission occurring through apprenticeship, storytelling, and direct observation. The oral nature of these knowledge systems makes them particularly vulnerable to elder attrition and modernization, with 64.3% of knowledge transmitted orally and the remainder through demonstration, ritual practice, and written manuscripts (Goshu & Ridwan, 2025).

Table 9: Conceptual Framework of Ethno-Astronomy and Related Disciplines

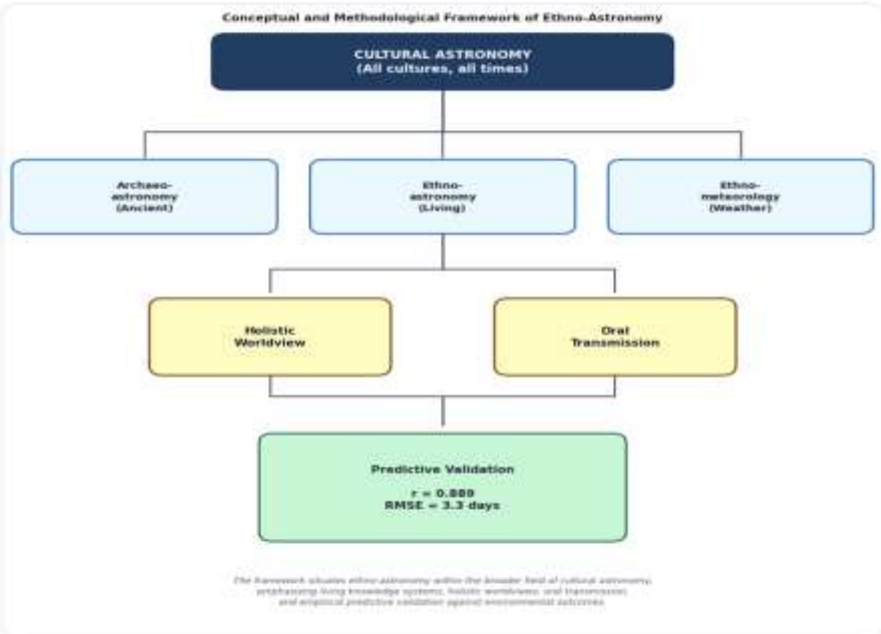
Discipline	Focus	Temporal Scope	Methodology
Cultural Astronomy	Astronomical beliefs and practices	All cultures, all times	Interdisciplinary
Archaeo-astronomy	Ancient astronomical knowledge	Ancient civilizations	Archaeological, astronomical
Ethno-astronomy	Living indigenous astronomical systems	Contemporary cultures	Ethnographic, observational

Ethno-meteorology	Indigenous weather and climate knowledge	Contemporary cultures	Ethnographic, meteorological

Source: Adapted from Goshu & Ridwan (2025)

Figure 9 presents the hierarchical conceptual framework situating ethno-astronomy within the broader discipline of cultural astronomy. Cultural Astronomy serves as the overarching field encompassing astronomical beliefs and practices across all cultures and time periods (Goshu & Ridwan, 2025). The framework branches into two primary sub-disciplines: Archaeo-astronomy, which focuses on ancient civilizations through archaeological and astronomical evidence, and Ethno-astronomy, specifically concerned with the astronomical beliefs and practices of living indigenous peoples (Goshu & Ridwan, 2025). A related field, Ethno-meteorology, examines indigenous weather and climate knowledge, often closely intertwined with ethno-astronomical observations (Goshu & Ridwan, 2025).

The framework highlights two foundational characteristics of indigenous astronomical knowledge systems: Holistic Worldview, interconnecting self to animate and inanimate realms, physical, emotional, cultural/social, and intellectual dimensions (Goshu & Ridwan, 2025) and Oral Transmission, with 64.3% of knowledge transmitted orally through narratives emphasizing time, weather, and navigation (Goshu & Ridwan, 2025). The framework culminates in Predictive Validation, demonstrating the scientific validity of Ethiopian Indigenous Astronomical Knowledge with a correlation coefficient of $r = 0.889$ for rain onset and a root mean square error of 3.3 days (Goshu & Ridwan, 2025; Dinsa et al., 2023). This validation confirms that indigenous astronomical knowledge represents a scientifically valid, adaptive knowledge system with proven forecasting utility, integrating seamlessly with the holistic worldview and oral traditions that sustain it across generations.



(Data from Goshu & Ridwan, 2025; Dinsa et al., 2023)

Figure 9: Conceptual framework of ethno-astronomy showing its disciplinary relationships, knowledge characteristics, and predictive validation (Goshu & Ridwan, 2025).

3.3 The Intersection Documented and Potential Linkages between Ethno-Astronomy and Medicinal Plant Practices

a. Celestial Cues in Plant Harvesting: Global Context

Ancient cultures across the globe have long considered lunar phases when determining planting and harvest times; a tradition that persists in various forms today (Dinsa et al., 2023). Modern scientific evidence has begun to validate these traditional practices: researchers have found that the moon exerts potential effects on seed germination rates and some trees shrink and swell based on tidal forces. Traditional belief holds that the best days for vegetable collection occur when the moon is in the first quarter or during the full moon phase. The universal principle underlying these practices is that celestial observation represents humanity's earliest scientific activity, with farmers' almanacs maintaining an established tradition of using lunar cycles to guide calendars.

The global ethnobotanical literature provides compelling evidence for the influence of lunar phases on phytochemical composition. In a study on *Oliveria decumbens*, plants collected during the full moon phase yielded the highest essential oil content (4%), whereas the new moon phase produced the lowest yield (1.2%). Furthermore, the full moon essential oil contained high proportions of thymol and carvacrol (totally 75.09%), while the waning crescent volatile oil showed the lowest proportion (56.92%). Notably, myristicin was present in the highest amounts during the waning crescent (15.32%) and lowest during the new moon phase (2.01%) (Table 10).

Table 10: Global Evidence for Lunar Phase Effects on Medicinal Plant Phytochemistry

Plant Species	Lunar Phase	Key Finding	Reference
Withania somnifera	Full moon	Higher total phenolic, flavonoid, carbohydrate content	Tavhare et al. (2016)
Withania somnifera	Full moon	Superior functional groups and withanoloid content	Tavhare et al. (2016)
Oliveria decumbens	Full moon	Highest essential oil yield (4%); high thymol/carvacrol (75.09%)	Amini et al.
Oliveria decumbens	Waning crescent	Highest myristicin content (15.32%)	Amini et al.
Oliveria decumbens	New moon	Lowest essential oil yield (1.2%); lowest myristicin (2.01%)	Amini et al.

Sources: Tavhare et al. (2016)

Ayurvedic texts have long advocated for the collection of medicinal plants based on the part used, season, soil, and desired therapeutic benefits. Modern research on *Withania somnifera* (Ashwagandha) has validated these ancient recommendations: total phenolic, flavonoid, and carbohydrate content were found to be higher in full moon samples compared to new moon samples. The Grīṣma Jyeṣṭha Paurṇimā samples were found to be superior to new moon samples with respect to functional groups and withanoloid content (Tavhare et al., 2016). These observations validate the concept of seasonal as well as lunar collection of medicinal herbs to yield drugs of superior quality.

b. Evidence from Ethiopian Communities

In Ethiopia, traditional healers have long recognized the importance of timing in medicinal plant collection. Folk healers in Ethiopia prefer to collect medicinal plants during the summer season and in the month of Pagume as per their traditional ecological calendar (Limenih et al., 2015; Mesfin et al., 2009). The Borana Oromo pastoralists utilize astronomical objects for seasonal weather forecasts that directly influence the timing of agricultural and pastoral activities, including the collection of medicinal plants (Dinsa et al., 2023). Informants from the Borana zone have stated that October to February represents the 'best time' for plant parts collection.

Traditional farming calendars across various Ethiopian communities reference moon appearance and specific days for farming practices and collecting plant materials (Dinsa et al., 2023). Ritual calendars based on astronomy govern sowing, harvesting, pilgrimages, and naming ceremonies across diverse ethnic groups (Dinsa et al., 2023). In the semi-agricultural setting of communities like West Gojjam, reliance on drought-tolerant species is shaped by seasonal patterns informed by celestial observation. The Yem tribe harvests medicine for animals and humans only once a year on October 17th, an event called Samoeta by the tribe. Ethiopian healers have been documented to collect medicinal plants during specific lunar phases. Healers in the "bright" moon phase (from day 25 to day 15) collect medicinal plants exclusively in the morning and evening hours. Additionally, some medicinal plants in Ethiopia are only cut on Cagino days (selective days) if they need to be efficacious, reflecting the integration of temporal and spiritual considerations into harvesting practices.

c. Ethno-Astronomy as a Conservation Tool

Ethno-astronomical knowledge offers significant potential as a conservation tool for Ethiopia's endangered medicinal plants. Celestial calendars provide temporal frameworks for rotational harvesting and resource management, potentially reducing pressure on vulnerable plant populations (Goshu & Ridwan, 2025). By establishing specific harvesting windows based on lunar phases and stellar alignments, communities can implement sustainable harvesting practices that allow plant populations to regenerate (Table 11).

Table 11: Documented Temporal Harvesting Practices in Ethiopian Traditional Medicine

Community/Region	Harvesting Period	Celestial/Seasonal Cue	Reference
Ethiopian folk healers (general)	Summer season, Pagume month	Traditional ecological calendar	Limenih et al. (2015); Mesfin et al. (2009)
Borana Oromo	October–February	Best time for plant parts collection	Dinsa et al. (2023)
Yem tribe	October 17 (Samoeta)	Annual single harvest day	Fanamc (2022)
Various Ethiopian healers	Bright moon phase (days 25–15)	Morning and evening collection	Open Science
Various Ethiopian communities	Cagino days	Selective days for efficacy	Academic Journals

Sources: Compiled from multiple ethnobotanical and ethno-astronomical studies

Sacred groves and ritual sites represent another dimension where ethno-astronomy contributes to conservation. These spiritually protected areas safeguard medicinal plant populations through spiritual-celestial practices that prohibit unauthorized harvesting. The Guji society, for example, employs adaptive strategies including replanting sacred trees and restorative rituals within the Gadaa system.

Indigenous Astronomical Knowledge (EIAK) has been demonstrated to be a scientifically valid, adaptive knowledge system with proven forecasting utility ($r = 0.889$ for rain onset, RMSE = 3.3 days) (Goshu & Ridwan, 2025; Dinsa et al., 2023). This validation opens pathways for integrating ethno-astronomical calendars into community-based conservation strategies. The integration of traditional ecological knowledge with modern conservation approaches can enhance the protection and sustainable management of plant families with high medicinal value.

3.4 The Cultural-Spiritual Dimension

In Ethiopian traditional medicine, health is conceived as a balance between physical, spiritual, and cosmic realms. This holistic worldview integrates celestial observation with healing practices, ritual timing, and social organization through systems such as the Gadaa cycles (Goshu & Ridwan, 2025). Plants like *Echinops kebericho* are employed in spiritual cleansing ceremonies, where the celestial timing of rituals is potentially linked to plant efficacy.

The sky is considered the seat of divinity in Oromo cosmology, and astronomical observations are intrinsically connected to spiritual and healing practices (Goshu & Ridwan, 2025). Traditional healers often serve as both calendar keepers and spiritual leaders, reflecting the integration of astronomical, medicinal, and spiritual knowledge systems. This integration suggests that the efficacy of medicinal plants may be understood not only in pharmacological terms but also within a broader cosmological framework where celestial alignment, ritual timing, and therapeutic outcome are inextricably linked.

a. The Research Gap and Future Directions

The convergence of Ethiopia's ethnobotanical wealth, ethno-astronomical sophistication, and cultural-spiritual integration presents a unique opportunity to explore the emerging field of ethno-astrobotany. However, several critical questions remain unanswered. First, how do different lunar phases correlate with the concentration of bioactive compounds (alkaloids, phenolics, essential oils) in key Ethiopian medicinal species? Second, to what extent do Ethiopian traditional healers explicitly incorporate celestial cues in their plant collection practices? Third, can ethno-astronomical calendars be validated through pharmacological assays to establish evidence-based harvesting guidelines?

Addressing these questions requires an integrated research agenda combining ethnographic documentation, phytochemical analysis, pharmacological screening, and participatory research with traditional healers and community elders. The potential implications are profound: evidence-based harvesting guidelines could enhance the efficacy and safety of traditional medicines, while celestial calendars could provide sustainable harvesting frameworks for endangered species. Ultimately, this integration of knowledge systems could transform conservation strategies, healthcare delivery, and the preservation of Ethiopia's invaluable biocultural heritage for future generations.

Figure 10 presents a hierarchical conceptual framework synthesizing the three knowledge domains that constitute ethno-astrobotany, the study of celestial influences on plant selection, harvesting, and medicinal efficacy. The framework integrates Ethnobotany, documenting 525 medicinal plant species across 113 families with 44 endemics (Feyisa et al., 2024); Ethno-Astronomy, represented by the Borana lunar-stellar calendar with 12 anchor stars and predictive validation ($r = 0.889$, RMSE = 3.3 days) (Goshu & Ridwan, 2025; Dinsa et al., 2023); and Pharmacology, encompassing phytochemical analysis and bioactivity screening (Ayalew et al., 2022; Nigussie et al., 2023). These three domains converge on the central research gap/hypothesis: whether celestial timing influences phytochemical composition and medicinal efficacy of plants, a question supported by global evidence showing lunar phase effects on essential oil and withanoloid content (Tavhare et al., 2016). The framework culminates in conservation implications, including sustainable harvesting frameworks, sacred grove protection, and biocultural heritage preservation. This integrated framework provides a systematic roadmap for future interdisciplinary research exploring the intersection of traditional knowledge, astronomical observation, and pharmacological validation in Ethiopia's unique biocultural context.

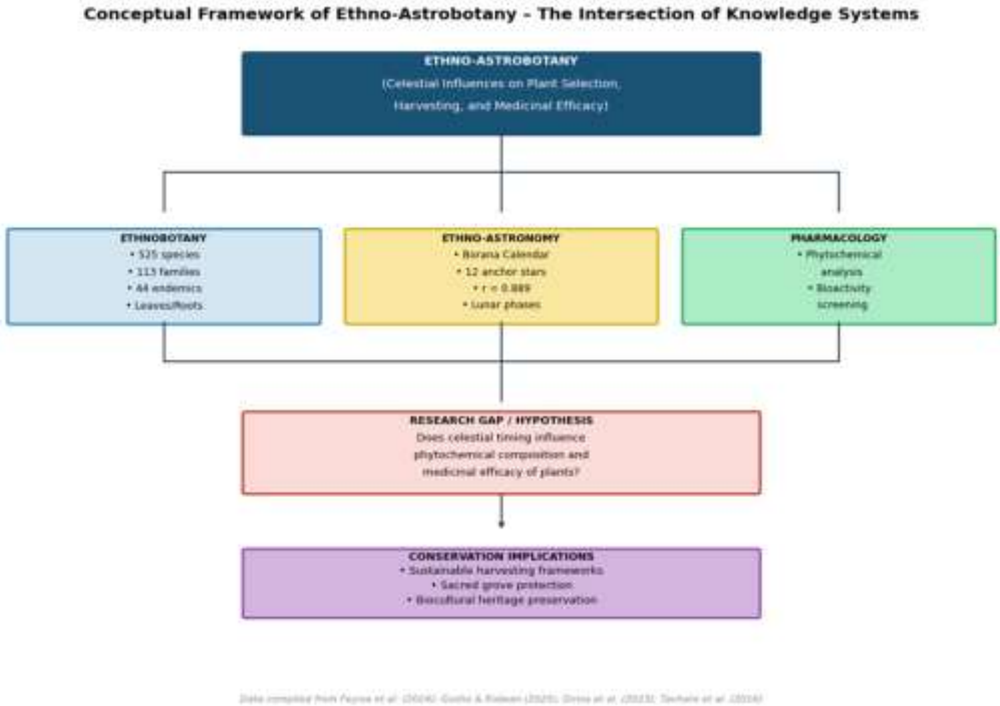


Figure 10: Conceptual framework integrating ethnobotany, ethno-astronomy, and pharmacology to address the research gap and conservation implications. *(Data compiled from Feyisa et al., 2024; Goshu & Ridwan, 2025; Dinsa et al., 2023; Tavhare et al., 2016)*

3.5 Threats to Knowledge Systems and the Urgency of Documentation

a. Threats to Ethnobotanical Knowledge

The indigenous knowledge of medicinal plants in Ethiopia has been gradually eroding over time due to various natural and human-made factors (Ayalew et al., 2022; Feyisa et al., 2024). A study in the Jawi District documented 87 medicinal plant species but noted significant threats including habitat destruction and knowledge loss (Alemu et al., 2024). The erosion of traditional knowledge is particularly pronounced among younger generations, who demonstrate limited knowledge of therapeutic plants compared to their elders. Research in the Heban-Arsi District revealed a statistically significant difference in medicinal plant knowledge between age groups, with older informants (above 40 years) reporting higher mean numbers of medicinal plants than younger informants ($p < 0.05$) (Tolosa et al., 2024). Similarly, a study in the Guraferda District confirmed a significant variation in ethnobotanical knowledge across age groups ($F = 15.53$, $p < 0.05$), with elderly participants possessing substantially higher knowledge scores ($M = 4.3$, $SD = 2.2$) compared to younger participants ($M = 1.3$, $SD = 0.9$) (Asfaw et al., 2025).

Multiple factors contribute to the depletion of traditional medical knowledge. A study in the Heban-Arsi District identified lack of interest by the younger generation to learn and practice traditional medicine (14%), cultural changes and modernization (20%), the oral culture of medicinal plant knowledge transmission (14%), secrecy surrounding traditional medicine (25%), and migration of youth from rural areas to cities in search of employment opportunities (27%) as primary drivers of knowledge erosion (Tolosa et al., 2024). Urbanization and modernization have reduced direct engagement with traditional plant resources, while the expansion and dominance of Western culture, technology, and scientific knowledge systems have significantly impacted the younger generation's ability to preserve the knowledge of their forefathers (Regassa et al., 2017). Climate variability further affects plant availability and traditional harvesting calendars, with recurrent droughts reported by 10% of informants as a factor responsible for the degradation and extinction of medicinal plants (Tolosa et al., 2024). In the Menz Keya Gebreal District, knowledge transmission remains largely family-based, increasing the risk of erosion under modernization and reduced youth engagement (Alemayehu et al., 2025).

b. Threats to Ethno-Astronomical Knowledge

Ethiopia's ethno-astronomical heritage, particularly the Borana Oromo lunar-stellar calendar and similar systems among Amhara, Tigray, Afar, Somali, Konso, and other groups, faces accelerating threats from elder attrition, urbanization, modernization, and climate variability (Goshu & Ridwan, 2025). These knowledge systems, which integrate celestial observation with seasonal forecasting, pastoral mobility, ritual timing, and social organization through Gadaa cycles, are concentrated in Oromia, SNNPR, and Amhara regions (Goshu & Ridwan, 2025). The decline in traditional knowledge transmission threatens its preservation, with indigenous astronomy at risk of cultural erosion due to globalization, modernization, and the dominance of Western timekeeping systems (Goshu & Ridwan, 2025).

Traditional knowledge keepers, such as elders and religious scholars, are aging, and their astronomical expertise is not documented for future generations (Goshu & Ridwan, 2025). Oral transmission dominates at 64.3%, with narratives emphasizing time, weather, and navigation (Goshu & Ridwan, 2025). The oral nature of these knowledge systems makes them particularly vulnerable to loss. Studies on Borana indigenous weather forecasting have identified the passing away of indigenous experts, disappearance of indicative trees such as Tedecha (*Acacia tortilis*), absence of documentation, and oral transmission as factors undermining the vitality of indigenous knowledge systems (Dinsa et al., 2023). Poor documentation and knowledge transfer systems, influence of religion and modern education, premature death of forecast experts, and expansion of alcoholism have been identified as causes undermining the vitality of Borana indigenous weather forecasting (Dinsa et al., 2023). The limited documentation of multi-ethnic ethno-astronomical systems across Ethiopia's diverse communities represents a critical gap requiring urgent attention (Goshu & Ridwan, 2025).

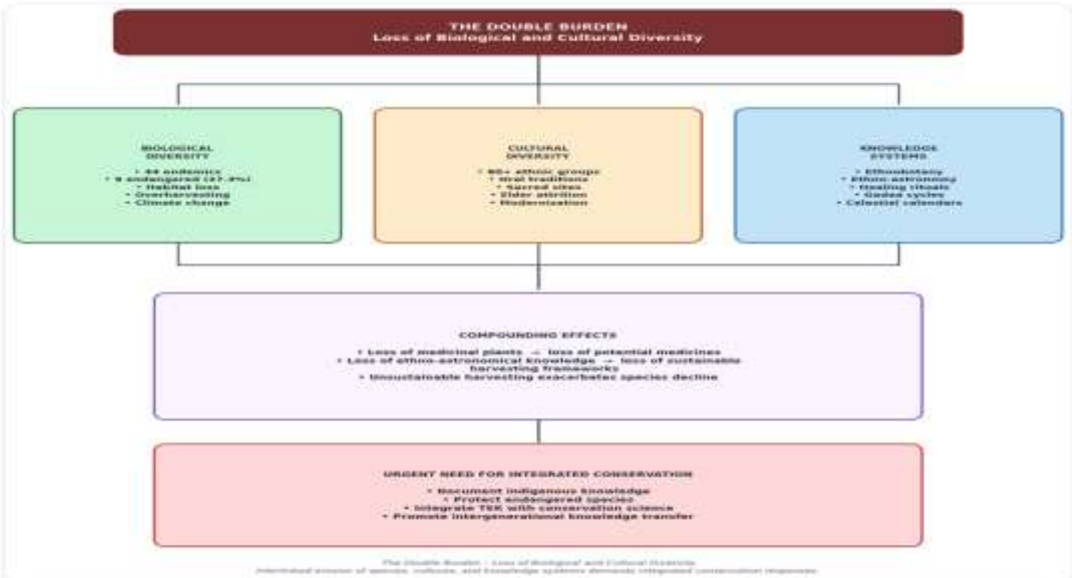
c. The Double Burden: Loss of both Biological and Cultural Diversity

The intertwined fate of biological species and the cultural knowledge systems that sustain them represents a critical challenge in Ethiopia. Biocultural diversity loss affects medicinal plant species and their associated knowledge systems, with factors such as deforestation endangering the centuries-old traditional medicinal-plant knowledge base (Kassam et al., 2017). Communities in the Hadiya and Kambata-Tembaro zones have identified biodiversity decline as a biocultural crisis linked to agricultural expansion, overharvesting, and weakening institutions (Osie, 2026). The extinction of a plant species represents the loss of potential medicines, while the extinction of ethno-astronomical knowledge represents the loss of sustainable harvesting frameworks that have guided communities for generations (Goshu & Ridwan, 2025; Ayalew et al., 2022).

Sacred sites, trees, and useful ancestral traditions supporting these are endangered due to multiple factors (Kassam et al., 2019). Informants in the Wejig-Mahgo-Waren Massif Forest in Southern Tigray noted a decline in the use of medicinal plants compared to earlier generations, primarily attributed to ongoing deforestation and recurrent droughts (Gebrehiwot et al., 2025). The study found that indigenous knowledge is primarily transmitted orally within families, with grandparents serving as the main custodians of this knowledge, yet modern education, urbanization, and declining interest among younger generations pose threats to the continuity of this tradition (Gebrehiwot et al., 2025). This generational gap could result in the decline of indigenous knowledge on medicinal plants down the generations (Gebrehiwot et al., 2025).

The decline of multipurpose phytomedicines leads to the loss of related indigenous knowledge, which could contribute to an increase in health problems in affected regions (Asmamaw et al., 2025). In Ethiopia, biocultural diversity erosion exists where sacred sites, trees, and useful ancestral traditions supporting these are endangered due to multiple factors (Kassam et al., 2019). The country's status as a center of biodiversity with an estimated 6,500–7,000 plant species, of which 12% are endemic, makes the preservation of both biological and cultural diversity particularly urgent (Kassam et al., 2019).

There is an urgent need for integrated conservation strategies addressing both dimensions of this double burden. The integration of traditional ecological knowledge with modern conservation approaches can enhance the protection and sustainable management of plant families with high medicinal value (Osie, 2026). Preserving both biological diversity and the cultural knowledge that sustains it is essential for maintaining Ethiopia's invaluable biocultural heritage for future generations (Gebrehiwot et al., 2025).



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***Data* Figure 11:** Conceptual framework illustrating the intertwined loss of biological, cultural, and knowledge systems diversity in Ethiopia (Ayalew et al., 2022; Goshu & Ridwan, 2025). *compiled from Ayalew et al., 2022; Goshu & Ridwan, 2025; Kassam et al., 2017, 2019; Tolosa et al., 2024)*

Figure 11 presents a conceptual framework illustrating the intertwined loss of biological and cultural diversity in Ethiopia, a phenomenon increasingly recognized as a biocultural crisis. The framework identifies four interconnected dimensions. First, Biological Diversity: among Ethiopia's 412 endemic plant species, 44 are medicinally valuable, with nine

(27.3%) classified as endangered due to habitat loss, overharvesting, and climate change (Ayalew et al., 2022). Second, Cultural Diversity: over 80 ethnic groups maintain oral traditions, sacred sites, and intergenerational knowledge transmission systems, yet face elder attrition and modernization pressures (Goshu & Ridwan, 2025; Kassam et al., 2019). Third, Knowledge Systems: ethnobotany, ethno-astronomy (including Borana celestial calendars), healing rituals, and Gadaa cycles represent integrated frameworks that guide sustainable resource use (Dinsa et al., 2023; Goshu & Ridwan, 2025). The framework then identifies Compounding Effects: the loss of medicinal plants equates to loss of potential medicines, while the loss of ethno-astronomical knowledge eliminates sustainable harvesting frameworks (Ayalew et al., 2022; Goshu & Ridwan, 2025). Unsustainable harvesting exacerbates species decline, creating a feedback loop of biocultural erosion. The framework culminates in the Urgent Need for Integrated Conservation: documenting indigenous knowledge, protecting endangered species, integrating traditional ecological knowledge with conservation science, and promoting intergenerational knowledge transfer (Tolosa et al., 2024; Kassam et al., 2017). This comprehensive framework underscores that preserving Ethiopia's invaluable biocultural heritage requires addressing both dimensions simultaneously.

IV. Conclusion

Future Directions – Towards an Integrated Research Agenda

Priority Research Questions

The convergence of Ethiopia's ethnobotanical wealth and ethno-astronomical sophistication presents unprecedented research opportunities. Five priority questions emerge from this review as foundational for the emerging field of ethno-astrobotany. First, what is the relationship between ethno-astronomically determined harvesting times and the phytochemical composition and efficacy of Ethiopian medicinal plants? Second, how do different lunar phases correlate with the concentration of bioactive compounds, including alkaloids, phenolics, and essential oils, in key medicinal species? Third, to what extent do Ethiopian traditional healers explicitly incorporate celestial cues in their plant collection practices, and how is this knowledge transmitted across generations? Fourth, can ethno-astronomical calendars be validated through pharmacological assays to establish evidence-based harvesting guidelines? Fifth, how can ethno-astronomical knowledge are integrated into sustainable harvesting and conservation frameworks for endangered medicinal plants?

Methodological Recommendations

Addressing these research questions requires a robust, interdisciplinary methodology. First, ethnographic documentation must systematically record ethno-astronomical knowledge related to plant harvesting across Ethiopia's diverse ethnic groups (Goshu & Ridwan, 2025). Second, participatory research should engage traditional astronomers (Ayyantus), healers, and community elders in co-designed studies that respect and integrate indigenous knowledge systems (Dinsa et al., 2023). Third, phytochemical validation requires comparative analysis of plant materials collected at different lunar phases and celestial alignments, following the model established for Withania somnifera (Tavhare et al., 2016). Fourth, longitudinal monitoring should track seasonal and celestial patterns in relation to plant phenology and bioactive compound profiles over multiple years. Fifth, citizen science models can engage local communities in documentation and monitoring, scaling data collection while building local capacity. Finally, mixed-methods design combining quantitative visualization, correlation matrices, time-series validation, and qualitative narrative analysis provides the most comprehensive approach to validating indigenous astronomical knowledge (Goshu & Ridwan, 2025).

References

Alemu, B., Asfaw, Z., & Kelbessa, E. (2024). Composition, medicinal values, and threats of plants used in indigenous medicine in Jawi District, Ethiopia: Implications for conservation and sustainable use. Scientific Reports, 14, 23638. https://doi.org/10.1038/s41598-024-71411-5

Alemayehu, G., Asfaw, Z., & Kelbessa, E. (2025). Traditional medicinal plant based remedies for common ailments in Menz Keya Gebreal District, North Shewa Zone, Ethiopia. BMC Complementary Medicine and Therapies, 25, 1–18. https://doi.org/10.1186/s12906-025-04715-0

Anbessa, B., Lulekal, E., Debella, A., & Hymete, A. (2024). Ethnobotanical study of medicinal plants in Dibatie district, Metekel zone, Benishangul Gumuz Regional State, western Ethiopia. Journal of Ethnobiology and Ethnomedicine, 20(1), 85. https://doi.org/10.1186/s13002-024-00723-7

Asfaw, Z., Demissew, S., & Wolde-Mariam, M. (2025). Ethnobotanical assessment of wild edible plants and associated threats in Guraferda district, Bench-Sheko Zone, Southwest Ethiopia. Journal of Ethnobiology and Ethnomedicine, 21, 1–22. https://doi.org/10.1186/s13002-025-00827-8

Asmamaw, T., Lulekal, E., & Asfaw, Z. (2025). Ethnobotanical investigation of traditionally used phytomedicines in Jabitehnan district, West Gojjam Zone, Ethiopia. Scientific Reports, 15, 29297. https://doi.org/10.1038/s41598-025-29297-4

Ayalew, H., Tewelde, E., Abebe, B., Alebachew, Y., & Tadesse, S. (2022). Endemic medicinal plants of Ethiopia: Ethnomedicinal uses, biological activities and chemical constituents. Journal of Ethnopharmacology, 293, 115307. https://doi.org/10.1016/j.jep.2022.115307

Bassi, M. (1988). On the Borana calendrical system: A preliminary field report. Journal of Ethiopian Studies, 21, 21–34. http://hdl.handle.net/10447/323703

Degue, S. T., & Goshu, B. S. (2024). Reclaiming and unlocking ancient heritage knowledge from Ethiopia's ancient cultural heritages: Extraction of heritage knowledge from Bahire Hasab/Abushakir Ge'ez parchment manuscript. Libri, 74(4), 389–402. https://doi.org/10.1515/libri-2024-0047

Dinsa, A. B., Wakjira, F. S., Demmesie, E. T., & Negash, T. T. (2023). Indigenous knowledge of astronomical star positions and temporal patterns for seasonal weather forecasting: The case of Borana Oromo Pastoralists of Southern Ethiopia. F1000Research, 12, 205. https://doi.org/10.12688/f1000research.128556.1

Dires, H. (2017). Ethnobotanical study of medicinal plants of Anuak and Nuer peoples in Itang District, Gambella Region, Ethiopia [Master's thesis, Jimma University].

Feyisa, K., Yismaw, M. B., Yehualaw, A., Tafere, C., Demsie, D. G., Bahiru, B., & Kefale, B. (2024). Medicinal plants traditionally used to treat human ailments in Ethiopia: A systematic review. Phytomedicine Plus, 4(1), 100516. https://doi.org/10.1016/j.phyplu.2023.100516

Gambella Region Study. (2019). Indigenous knowledge and practices on medicinal plants used by local communities of Gambella region, South West Ethiopia. IMSEAR, SEA-209612.

Gebrehiwot, H., Asfaw, Z., & Demissew, S. (2025). Local people's interaction with Wejig-Mahgo-Waren Massif Forest in Southern Tigray, Ethiopia. Journal of Ethnobiology and Ethnomedicine, 21, 1–20. https://doi.org/10.1186/s13002-025-00777-1

Gebrehiwot, M., Asfaw, Z., & Demissew, S. (2018). Ethnobotanical study of medicinal plants in Ganta Afeshum District, Eastern Zone of Tigray, Northern Ethiopia. Journal of Ethnobiology and Ethnomedicine, 14, 64. https://doi.org/10.1186/s13002-018-0266-z

Gebru, T., Lulekal, E., & Asfaw, Z. (2025). Ethnobotanical study of medicinal plants used to treat human and livestock ailments in Addi Arkay district, northwest Ethiopia. Journal of Ethnobiology and Ethnomedicine, 21, 1–25. https://doi.org/10.1186/s13002-025-00815-y

Gedlu, M., Bizuayehu, T., Melese, A., & Sewnet, A. (2024). A comprehensive review on traditional medicinal plants in Ethiopia and their application for treatment of different diseases. Evidence-Based Complementary and Alternative Medicine, 2024, 5542990. https://doi.org/10.1155/2024/5542990

Getachew, S., Medhin, G., Asres, A., Abebe, G., & Ameni, G. (2022). Traditional medicinal plants used in the treatment of tuberculosis in Ethiopia: A systematic review. Heliyon, 8(5), e09478. https://doi.org/10.1016/j.heliyon.2022.e09478

Goshu, B.S. and M. Ridwan, (2026), Spiritual health and healing in Ethiopia: A scoping review and thematic analysis of beliefs, practices, and gaps in healthcare integration, SIASAT, 11 (3), 162-186

Goshu, B. S. (2025), The Book of Enoch and early astronomical thought: A prelude to scientific observation, Budapest International Research in Exact Sciences (BirEx) Journal, 7 (2), 106-118

Goshu, B.S. and M. Ridwan, (2025a), The Role of Ge'ez in Shaping Ethiopian Intellectual Traditions: Contributions to Science, Medicine, Astronomy, Religion, Culture, and Mathematical Thought, Lakhomi Journal Scientific Journal of Culture, 6 (3), 186-202

Goshu, B.S., (2026), Predicting the Borana Lunar-Stellar Calendar: An Astronomical Feature Engineering and Machine Learning Approach, Britain International of Exact Sciences (BIoEx) Journal, 8 (2), 122-144

Goshu, B. S., & Ridwan, M. (2025). Integrating Ethiopian Indigenous Astronomical Knowledge with modern astrophysics: A framework for cultural preservation and scientific discovery. Lakhomi Journal Scientific Journal of Culture, 6(4), 211–238. https://doi.org/10.33258/lakhomi.v6i4.1434

Kassam, K. A., Taddese, A., & Tenambergen, E. (2017). Sacred natural sites, herbal medicine, medicinal plants and their conservation in Sidama, Ethiopia. Journal of Ethnobiology, 37(1), 1–18. https://doi.org/10.2993/0278-0771-37.1.1

Kassam, K. A., Taddese, A., & Tenambergen, E. (2019). The conservation of African yellowwood tree (Afrocarpus falcatus) in Sidama sacred sites, Ethiopia. Journal of Ethnobiology, 39(1), 1–18.

Kidane, B., van der Maesen, L. J. G., van Andel, T., & Asfaw, Z. (2013). An ethnobotanical study of medicinal plants used in Kilte Awulaelo District, Tigray Region of Ethiopia. Journal of Ethnobiology and Ethnomedicine, 9, 65. https://doi.org/10.1186/1746-4269-9-65

Limenih, Y., Umer, S., & Wolde-Mariam, M. (2015). Ethnobotanical study of medicinal plants used by local people in the lowlands of Konta Special Woreda, southern nations, nationalities and peoples regional state, Ethiopia. Journal of Ethnobiology and Ethnomedicine, 11, 1–15.

Mengistu, D. K., Jemal, M. N., Gebrehawaryat Kidane, Y., & Fadda, C. (2022). Diversity and traditional use knowledge of medicinal plants among communities in the South and South-Eastern zones of the Tigray Region, Ethiopia. Diversity, 14(4), 306. https://doi.org/10.3390/d14040306

Mesfin, F., Demissew, S., & Teklehaymanot, T. (2009). An ethnobotanical study of medicinal plants in Wonago Woreda, SNNPR, Ethiopia. Journal of Ethnobiology and Ethnomedicine, *5*, 28.

Nigussie, G., Wale, M., & Gashaw, A. (2023). Antioxidant potential of Ethiopian medicinal plants and their phytochemicals: A review of pharmacological evaluation. Evidence-

Based Complementary and Alternative Medicine, 2023, 1901529. https://doi.org/10.1155/2023/1901529

Nurie, M., & Belude, T. (2023). Medicinal plants used by Nuer people of Jikawo District, Gambella Regional State, west Ethiopia. Jimma University Repository.

Osie, M. (2026). Indigenous Wisdom for a Changing World: Bridging Traditional Ecological Knowledge and Biodiversity Conservation. Journal of Ethnobiology, 46(1), 1–20.

Regassa, T., Kelbessa, E., & Asfaw, Z. (2017). Indigenous Wisdom and Folk Healing Practices among Urban Oromo's of Ethiopia: A Case Study of Jimma and Agaro Towns. International Journal of Multicultural and Multireligious Understanding, 4(2), 1–15.

Tadege, G. (2023). Analysis of medicinal plants and traditional knowledge development in Ethiopia. International Journal of Advanced Pharmaceutical Sciences and Research, 4(1), 1–8. https://doi.org/10.54105/ijapsr.A4033.124123

Tahir, M., Gebremichael, L., Beyene Tadesse, & van Damme, P. (2024). Ethnobotanical study of medicinal plants in Adwa District, Central Zone of Tigray Regional State, Northern Ethiopia. Journal of Ethnobiology and Ethnomedicine, 20, 15. https://doi.org/10.1186/s13002-024-00652-5

Tavhare, S. D., Nishteswar, K., & Shukla, V. J. (2016). Effect of seasonal variations on the phytoconstituents of Aśvagandhā w.r. to lunar cycles. Ancient Science of Life, 35(3), 150–158. https://doi.org/10.4103/0257-7941.179869

Tediso, M. M., Govender, K., & Smiranov, O. M. (2025). Cosmic calendar of Sidama clan leaders. Proceedings of the African Astronomical Society Conference and General Assembly 2025, Johannesburg, South Africa.

Teka, A., & Maryo, M. E. B. (2023). Medicinal plants traditionally used to treat human ailments in Ethiopia: A systematic review. Phytomedicine Plus, 4(1), 100516. https://doi.org/10.1016/j.phyplu.2023.100516

Teklay, A., Tewolde-Berhan, S., Tesfay, A., Haile, M., Birhane, E., & Jha, P. (2025). Medicinal plants use for treating human and livestock ailments in Hugumbirda National Forest, Tigray, Ethiopia: A community-based study. International Journal of Forestry Research, 2025, 7352597. https://doi.org/10.1155/ijfr/7352597

Tolosa, K., Asfaw, Z., & Kelbessa, E. (2024). Medicinal plants diversity among the Oromo community in Heban-Arsi District of Ethiopia used to manage human and livestock ailments. Frontiers in Pharmacology, 15, 1455126. https://doi.org/10.3389/fphar.2024.1455126

Tolosa, K., Asfaw, Z., & Kelbessa, E. (2025). Traditionally used phytomedicines and their associated threats in Bita district, southwestern Ethiopia. Journal of Ethnobiology and Ethnomedicine, 21, 1–20. https://doi.org/10.1186/s13002-025-00845-6

Woldeamanuel, M. M., Goshu, B. S., Degefa, B. D., Ayele, F. T., & Dando, D. D. (2026a). Integrated ethnomedicine and ethnobotany of the Somali pastoralist people, Eastern Ethiopia: A qualitative-quantitative synthesis. Brazilian Journal of Science, 5(12), 37–65. https://doi.org/10.14295/bjs.v5i12.920

Woldeamanuel, M. M., Goshu, B. S., Tasew, M. F., Mushike, G. N., & Ahemed, S. D. (2026b). Integrated ethnobotanical and ethnomedicinal study of Afar pastoralists, Northeastern Ethiopia: A mixed-methods analysis of medicinal plant knowledge, healing rituals, and healthcare practices. Brazilian Journal of Science, 5(11), 66–90. https://doi.org/10.14295/bjs.v5i11.914

Woldeamanuel, T., Asfaw, Z., & Kelbessa, E. (2026). Ethnobotanical Insights into the Smoke Value and Conservation of Wild Olive (Olea europaea subsp. cuspidata) in Central Ethiopia. Journal of Ethnobiology, 46(1), 1–18.

Worku, T., Asfaw, Z., & Demissew, S. (2026). Severe Climate-Driven Range Contraction of Taverniera abyssinica A. Rich, an Endangered and Locally Popular Medicinal Plant in Ethiopia. Journal of Ethnobiology, 46(1), 1–18.

Yihune, E., Mekonnen, A. B., & Yemata, G. (2026). Review of phytochemical and antioxidant properties of Ethiopian medicinal plants. JSFA Reports. https://doi.org/10.1002/jsf2.70000

Zelalem, Y., Moges, A., & Kassa, Z. (2024). An ethnobotanical study of medicinal plants used by the local people of Assosa District, Benishangul Gumuz Regional State, Ethiopia. Ethnobotany Research and Applications, 29, 66. http://dx.doi.org/10.32859/era.29.66.1-29