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Traditional Medicinal Plant Utilization, Conservation, and Economic Valuation in Bori Mountain, Yem Zone, Central Ethiopia Regional State

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Abstract

Traditional medicinal plants are vital to healthcare, especially in regions with limited modern medical access. In Ethiopia, these plants have significant cultural, ecological, and economic importance. The study aims to document the diversity of ''Samoa ETA'' traditional medicinal plants, assess their ecological status, investigate traditional knowledge and practices, evaluate their economic value, and analyze policies regarding their conservation and sustainable use. A sample of 384 participants, including 10 traditional healers, 10 kebeles, and 4 woredas, will be selected from a population of 122,419. A stratified random sampling and systematic sampling method ensures representation across diverse ecological zones and socio-cultural groups. The research employs a multidisciplinary approach, combining ethnobotanical surveys, ecological assessments, and economic analyses. Ethnobotanical surveys will document the uses, preparation methods, and cultural significance of these plants. Ecological assessments will examine their distribution, abundance, and conservation status. A mixed-methods approach will integrate quantitative surveys analyzed using SPSS 26 and qualitative interviews thematically analyzed. Economic valuation will assess the monetary value and contribution to local livelihoods and national economies. The study aims to enhance understanding of the ''Samoa ETA'' medicinal plant diversity, ecological status, and traditional knowledge. It will provide insights into their economic value, inform conservation strategies that respect local customs, and promote sustainable management practices benefiting both the environment and local communities. Ultimately, this research seeks to ensure the continued availability and use of traditional medicinal plants for current and future generations.

Keywords

Traditional Medicinal Plants, Samoa Eta, Utilization, Conservation, Economic Valuation, Bori Mountain, Yem Zone

1. Introduction

1.1. Background

Medicinal plants have been globally recognized for their significant contribution to healthcare and the pharmaceutical industry. According to the World Health Organization (WHO), approximately 80% of the world's population relies on traditional, plant-based medicine for their primary healthcare

needs [6]. The demand for medicinal plants and herbal products is steadily rising, driven by several factors, including the increasing preference for natural remedies, the search for new drug leads, and the need for more accessible and affordable healthcare options.

Africa is known for its rich biodiversity and a long tradition of using medicinal plants in healthcare. Traditional medicine systems in countries such as Nigeria, South Africa, and Ghana heavily depend on medicinal plants to treat various ailments [65]. However, unsustainable harvesting practices, habitat loss, and inadequate regulatory frameworks present significant challenges to the conservation and sustainable use of medicinal plants in Africa [23]. Initiatives like the African Medicinal Plants Database are being implemented to address these issues by documenting and promoting the sustainable use of medicinal plants across the continent [70].

Ethiopia has a rich biodiversity and a long history of traditional medicine. The country's diverse ecosystems support a wide variety of medicinal plant species, which are integral to the healthcare practices of local communities [108]. However, the sustainability of these resources is threatened by unsustainable harvesting, land degradation, and inadequate policies and regulations [76]. Efforts like the Ethiopian National Biodiversity Strategy and Action Plan aim to conserve and sustainably use the country's biodiversity, including medicinal plants [53].

The conservation, sustainable use, and economic valuation of medicinal plants are of global importance. Ethiopia faces unique challenges and opportunities in managing these valuable resources. By prioritizing sustainable practices, strengthening regulatory frameworks, and promoting community involvement, it is possible to ensure the long-term availability of medicinal plants while supporting biodiversity conservation and improving the socioeconomic well-being of local communities.

Medicinal plants have been used in various traditional medicine systems, such as Ayurveda, Traditional Chinese Medicine, and Indigenous healing practices, for thousands of years [52]. These plants contain a wide range of chemical compounds, including alkaloids, flavonoids, terpenoids, and phenolics, which have shown therapeutic properties [31]. The therapeutic potential of medicinal plants spans from treating common ailments and chronic diseases to life-threatening conditions. Recently, there has been a growing interest in utilizing medicinal plants as alternative or complementary medicines, driven by their perceived safety, effectiveness, and cultural acceptance [66]. As a result, the global market for herbal medicines has grown significantly, contributing substantially to the economy [107].

However, unregulated exploitation and unsustainable harvesting practices have led to ecological and socioeconomic challenges. Many medicinal plant species are now threatened due to habitat loss, overharvesting, and illegal trade [90]. This loss not only disrupts ecosystems but also deprives local communities of valuable traditional healthcare resources and

economic opportunities. To address these challenges, various conservation strategies are being implemented. These include the establishment of protected areas, both in situ and ex situ conservation programmers, and the promotion of sustainable harvesting practices [86]. Additionally, economic valuation methods—such as market surveys, cost-benefit analysis, and value chain assessments—have been employed to assess the economic value of medicinal plants and incentivize their sustainable management [72]. Recognizing the economic value of these resources can further encourage their protection and foster sustainable management practices.

Despite their significance, there remains a gap in understanding the full extent of medicinal plant diversity in regions like Ethiopia, as well as the socioeconomic dynamics surrounding their exploitation and conservation. This study aims to fill these knowledge gaps by comprehensively assessing the medicinal plants in the Yem District and the Bori Mountain region of central Ethiopia. The research will focus on their ecological significance, traditional uses, conservation status, and economic potential [81].

Specifically, the study will document the diversity of medicinal plants, assess their ecological status and distribution, and explore local traditional knowledge and practices. It will also evaluate the economic significance of these plants through market surveys, trade patterns, and income generation. Furthermore, the study will review existing policies, regulations, and institutional frameworks related to the conservation and sustainable use of medicinal plants, providing recommendations for improvement.

The findings and recommendations of this study will contribute to informed decision-making, policy formulation, and capacity-building efforts, promoting the conservation, sustainable use, and economic valuation of medicinal plants in Ethiopia and beyond.

1.2. Research Problem

The Bori Mountain area in the Yem district of the Central Ethiopia Regional State is renowned for its rich biodiversity, particularly its diverse array of medicinal plants, which play significant roles in cultural, ecological, and economic spheres. However, there are no studies on remnant natural vegetation and in-depth ethnobotanical investigations previously conducted in the Yem Zone, except for a single report on agroforestry uses and practices of indigenous trees by [57] and an inventory of woody species in the Kamuli natural forest by [109]. There were no previous ethnobotanical reports or investigations. However, despite these medicinal plant resources, it is important to identify problems related to conservation, utilization, and economic evaluation.

The conservation of medicinal plants in the Bori Mountain area may face threats such as habitat degradation, deforestation, overharvesting, and unsustainable land use practices [16]. These challenges endanger the long-term sustainability of medicinal plant populations and the ecosystems they inhabit.

Utilization Issues: Although local communities extensively utilize medicinal plants for healthcare purposes, there are concerns regarding overexploitation, inappropriate harvesting techniques, and the absence of sustainable management practices [35]. Understanding the utilization patterns and their impacts on medicinal plant populations is essential for ensuring their sustainable use. Economic valuation concerns: Despite the economic significance of medicinal plants, there exists a lack of comprehensive economic valuation in the Bori Mountain area [67].

This deficiency hinders the assessment of their monetary value, understanding of their contribution to local economies, and development of sustainable income-generating opportunities for communities. Knowledge Gap: There may be gaps in documenting traditional knowledge associated with medicinal plants, including their uses, indigenous harvesting methods, and cultural significance [38]. Addressing these knowledge gaps is crucial for preserving traditional wisdom and formulating effective conservation and management strategies. The research problem revolves around understanding and addressing the challenges faced in the conservation, utilization, and economic valuation of medicinal plants in the Bori Mountain area of the Yem Zone, Central Ethiopia Regional State [108]. By tackling these challenges, the study aims to contribute to the sustainable management and utilization of medicinal plant resources for the benefit of local communities and the broader ecosystem.

2. Literature Review

2.1. Vegetation of Ethiopia

Ethiopia is a biodiversity hotspot, home to two of the world's 35 biodiversity hotspots: the Eastern Afromontane and the Horn of Africa [21]. The country's rich vegetation, shaped by diverse topography, climate, and soil types, ranges from afroalpine zones to desert scrublands [42]. Ethiopia boasts over 6,000 plant species, with about 10% being endemic [83]. The country is also a key center of origin for important crops such as teff, enset, and coffee, playing a vital role in global agriculture [105]. Ethiopia's vegetation is critical for ecosystem services like water regulation and climate change mitigation, as well as supporting local economies through agriculture, traditional medicine, and forest products [41]. However, significant deforestation has reduced the forest cover from about 40% in the 1950s to 16% in the 1990s, causing biodiversity loss and exacerbating environmental challenges [67]. Despite efforts to combat deforestation, more action is needed to preserve these ecosystems [40]. Ethiopia's varied vegetation types, from afroalpine zones to dry lowland woodlands, host unique species and provide crucial ecological functions such as soil conservation and wildlife habitats [80].

Traditional medicinal plant use has been a significant part of Ethiopia's healthcare system for centuries. In the Bori Mountain region of the Yem Zone, a rich variety of medicinal plants are used by local communities for treating numerous ailments [2]. However, overharvesting and habitat destruction threaten these valuable plant resources. Conservation efforts are vital to ensure the sustainability of traditional medicinal plants for future generations [95]. These plants also have the potential to generate income for local communities through sustainable harvesting and trade, contributing to both biodiversity conservation and economic growth [62]. The importance of medicinal plants in local healthcare practices, their conservation, and their economic potential are significant aspects of Ethiopia's natural heritage.

Ethiopia's diverse vegetation includes afroalpine and sub-afroalpine zones, found at elevations above 3,200 metres in the Ethiopian Highlands. These areas are characterised by cold temperatures, frost, and snow and are home to unique plant species such as giant lobelias (Lobelia rhynchopetalum) and giant senecios (Senecio johnstonii), which are vital for endemic wildlife, including the endangered Ethiopian wolf (Canis simensis) [8]. The mid-altitude forests between 1,800 and 3,200 meters feature species like Ethiopian cedar (Juniperus procera) and African olive (Olea europaea subsp. cuspidata), supporting biodiversity and providing essential services such as water catchment and timber production [71]. In the central and northern highlands, forests and grasslands play a crucial role in agriculture and grazing while also aiding soil conservation and water regulation [95].

Moist Evergreen Afromontane forests thrive in the southwestern and southeastern highlands under high rainfall and humidity, home to species like Prunus africana and Pouteria adolfi-friedericii. These forests provide vital services such as carbon sequestration and climate regulation [51]. In contrast, Acacia-Commiphora woodlands dominate the arid lowlands, particularly in the east and southeast, where they support pastoralism, traditional medicine, and dry-adapted wildlife species [88]. Combretum-Terminalia woodlands and savannas in the west and northwest are crucial for agriculture and grazing, supporting a range of wildlife and providing wood products [87]. Desert and semi-desert scrublands in the northeastern and southeastern lowlands are home to drought-resistant species like cacti and succulents, vital for nomadic pastoralism [106]. Wetlands along rivers, lakes, and floodplains support diverse plant species like papyrus (Cyperus papyrus) and are essential for water purification, flood control, and agriculture [29].

Despite the pressures of deforestation, climate change, agricultural expansion, and overgrazing, the conservation of Ethiopia's vegetation is crucial for maintaining the ecological balance. Protected areas, sustainable land management, and community-based conservation efforts are essential to preserve the country's rich vegetation and the services it provides.

2.2. The Science of Ethnobotany: Inception, Scope, and Application

Ethnobotany, the scientific study of the relationships between people and plants, has its roots in the late 19th century, when the term was first coined by American botanist John William Harshberger in 1895. Ethnobotany focuses on understanding how various cultures use plants for medicinal, nutritional, and utilitarian purposes, integrating knowledge from anthropology and botany [22]. The scope of ethnobotany is broad, covering areas such as traditional medicine, where researchers document and analyze plant-based remedies used by indigenous communities; food plants, which includes the study of traditional agricultural practices and wild edible plants; material culture, exploring how plants are used in making tools, textiles, and shelter; and ritual and symbolism, which looks at the cultural and religious significance of plants [85].

The application of ethnobotany is extensive and impactful, particularly in drug discovery, where many modern pharmaceuticals, such as artemisinin for malaria, have been derived from plants traditionally used in local medicine [99]. Ethnobotanical knowledge also contributes to agricultural innovation by informing sustainable practices and enhancing food security through the documentation of traditional crop varieties and farming techniques. Furthermore, ethnobotany plays a crucial role in conservation efforts by highlighting the ecological importance of plant species and promoting sustainable use practices while also aiding in cultural preservation by recording the botanical knowledge of indigenous and local communities [69]. The economic potential of ethnobotany is significant, with the commercialization of traditional plant products offering new opportunities for economic development in local communities. Overall, ethnobotany enriches our understanding of human- plant interactions and provides practical solutions to contemporary challenges in health, agriculture, and environmental conservation.

2.2.1. Application of Ethnobotanical Research

Ethnobotanical research has wide-ranging applications that significantly impact medicine, agriculture, conservation, and socio-economic development. One of the most prominent applications is in drug discovery and development. Many modern pharmaceuticals have their origins in plants traditionally used by indigenous communities; for example, the anti-malarial drug artemisinin was derived from Artemisia annua, a plant used in Traditional Chinese Medicine [29]. This field continues to be a vital source of new medicinal compounds as ethnobotanists document traditional knowledge and identify plants with therapeutic potential. In agriculture, ethnobotanical research informs sustainable practices and enhances food security by preserving traditional knowledge about crop varieties, agricultural techniques, and pest management. For instance, indigenous practices of crop rotation and companion planting can lead to more sustainable farming methods [69]. Conservation efforts also benefit from ethnobotanical research, as it highlights the ecological significance of plant species and promotes sustainable use practices,

thereby aiding in the preservation of biodiversity and ecosystems. Ethnobotanical studies often result in community-based conservation programs that integrate traditional knowledge into effective management plans [100]. Furthermore, the economic applications of ethnobotanical research are substantial. The commercialization of traditional plant products, such as herbal medicines, cosmetics, and crafts, provides new economic opportunities for local communities, promoting sustainable development and cultural preservation. By bridging traditional knowledge and modern science, ethnobotanical research offers practical solutions to contemporary challenges and fosters a more profound understanding of the intricate relationships between people and plants.

2.2.2. Research methods in Ethnobotany

Research methods in ethnobotany are diverse and interdisciplinary, integrating techniques from anthropology, botany, and ecology to comprehensively study the relationships between people and plants. One fundamental method is participant observation, where ethnobotanists immerse themselves in the daily lives of indigenous or local communities to observe and document plant use practices in their natural context [18]. Ethnographic interviews are also crucial, involving structured or semi-structured interviews with community members to gather detailed information on the uses, preparation, and cultural significance of various plants [5]. Herbarium specimen collection and botanical identification are vital for scientifically documenting the plant species studied, ensuring accurate taxonomic identification, and preserving voucher specimens for future reference [56]. Quantitative methods such as surveys and questionnaires help in gathering data on the frequency and extent of plant use within communities, which can be statistically analyzed to identify patterns and trends [4]. Additionally, phytochemical analysis is often conducted to isolate and identify the active compounds in medicinal plants, bridging traditional knowledge with modern scientific validation [12].

GIS mapping and ecological surveys are used to study the distribution and abundance of useful plants, aiding in conservation planning and sustainable management of plant resources [11]. Collectively, these methods enable ethnobotanists to systematically document traditional knowledge, understand cultural practices, and contribute to the conservation and sustainable use of plant resources.

2.2.3. Ethnobotanical Research in Ethiopia

Ethnobotanical research in Ethiopia is rich and diverse, reflecting the country's exceptional biodiversity and cultural heritage. Ethiopia is home to a wide array of medicinal plants used by diverse ethnic groups for centuries to treat various ailments and promote health. The study of ethnobotany in Ethiopia explores traditional knowledge systems, plant use practices, and medicinal properties embedded within local communities [47]. Researchers document indigenous

knowledge associated with medicinal plants, contributing to the conservation and sustainable use of biodiversity while supporting community health care practices [45]. Ethiopia's unique ecological zones, from highland forests to arid lowlands, provide a natural laboratory for studying plant diversity and adaptation to environmental challenges [51]. Ethnobotanical studies in Ethiopia preserve cultural heritage and inform modern pharmacological research, identifying potential sources of new drugs and therapeutic compounds that contribute to global health advancements.

2.3. Traditional Medicinal Plant Utilization

Traditional medicinal plant utilization refers to the practice of using plants and their extracts for therapeutic purposes, which is deeply embedded in the cultural practices and knowledge systems of various societies. This ancient practice forms the foundation for many modern medicines and continues to be a significant source of health care, especially in developing countries. Traditional medicinal plant utilization can be traced back to ancient civilizations. For example, the Ebers Papyrus (circa 1550 BC) in Ancient Egypt is one of the oldest medical documents detailing numerous plant-based treatments for various ailments.

In India, Ayurvedic medicine, one of the world's oldest medical systems, uses plants like turmeric, neem, and ashwagandha. Traditional Chinese Medicine (TCM) in China relies on plants such as ginseng, ephedra, and liquorice for their healing properties. In Greece and Rome, Hippocrates and Galen documented the medicinal uses of many plants, laying the groundwork for Western herbal medicine. Traditional Chinese Medicine (TCM) showcases a rich tradition that incorporates plants like ginseng (Panax ginseng), astragalus (Astragalus membranaceus), and goji berry (Lycium barbarum). These plants are revered for their adaptogenic properties, immune support, and longevity-promoting benefits, reflecting a comprehensive approach to health maintenance and disease prevention [106]. Several plants have been widely used across cultures for their medicinal properties. Willow bark has been used since ancient times for pain relief and fever, containing salicin, which led to the development of aspirin. Turmeric (Curcuma longa) is known for its anti-inflammatory and antioxidant properties and is a staple in Ayurvedic medicine. Ginseng is used in TCM to boost energy, reduce stress, and improve cognitive function. Peppermint (Mentha piperita) is used for digestive issues and as a topical analgesic for muscle pain.

Traditional medicinal plants are prepared using various methods to extract their active compounds. Infusions involve steeping plant material in hot water, similar to making tea. Decoctions are used for tougher plant parts like roots and bark, which are boiled to extract the active constituents. Tinctures are created by soaking plant materials in alcohol or another solvent to extract their active compounds. Poultices involve mashing fresh or dried plant materials and applying them

directly to the skin to treat wounds or inflammation. Many traditional medicinal plants have gained scientific validation. Artemisinin, derived from sweet wormwood (Artemisia annua), is now a key antimalarial drug. Digitalis, extracted from foxglove (Digitalis purpurea), is used to treat heart conditions. Morphine, derived from the opium poppy (Papaver somniferum), is a powerful painkiller. These examples demonstrate the transition from traditional use to modern pharmaceutical applications, emphasizing the importance of preserving ethnobotanical knowledge.

However, there are challenges and considerations in the utilization of traditional medicinal plants. Overharvesting of wild medicinal plants can lead to the depletion of resources and threaten biodiversity. Traditional methods can result in variations in potency and efficacy, highlighting the need for standardized preparations. Despite their potential, many medicinal plants require further clinical trials to ensure their safety and efficacy for integration into modern medical practices. Ethnobotany plays a crucial role in drug discovery by documenting traditional knowledge and identifying plants with medicinal potential. For example, the Samoa eta plant from Bori Mountain is noted for its potential medicinal properties, demonstrating the value of indigenous knowledge in discovering new therapeutic agents. Traditional medicinal plants are vital to global health care, offering a rich source of potential new drugs. Preserving traditional knowledge and ensuring sustainable practices are essential for maintaining this valuable resource. Traditional medicinal plant utilization is the practice of using plants and their extracts for therapeutic purposes, deeply embedded in the cultural practices and knowledge systems of diverse societies worldwide.

These plants have historically served as essential components of healthcare in indigenous and traditional medicine systems, offering remedies for various ailments based on accumulated wisdom and experience passed down through generations. The importance and cultural significance of traditional medicinal plant utilization extend beyond mere healthcare provision. These practices are integral to preserving cultural heritage and biodiversity. Traditional remedies often reflect a profound connection between communities and their natural environments, embodying local knowledge about plant-based healing that has been refined over centuries of use. Examples from different traditional medicine systems illustrate the diversity and efficacy of medicinal plants.

In Ayurvedic medicine, practiced predominantly in India, plants like neem (Azadirachta indica), turmeric (Curcuma longa), and tulsi (Ocimum tenuiflorum) are valued for their therapeutic properties, such as antibacterial, anti-inflammatory, and immune-modulating effects, contributing significantly to holistic health approaches [107]. Similarly, Western herbal medicine traditions in Europe utilize plants such as chamomile (Matricaria chamomilla), valerian (Valeriana officinalis), and St John's wort (Hypericum perforatum). These plants are known for their calming, sedative, and antidepressant effects, offering natural alternatives to

conventional pharmaceuticals and contributing to the growing interest in integrative medicine [19]. The methods of utilizing traditional medicinal plants vary widely and are tailored to specific plants and therapeutic purposes. Preparation methods include teas, decoctions, tinctures, poultices, and oils, each chosen for its ability to extract and preserve beneficial compounds effectively [49].

Conservation and sustainability are crucial considerations in the utilization of traditional medicinal plants. Sustainable harvesting practices, habitat conservation, and the preservation of traditional knowledge are essential for maintaining the availability of these valuable resources. By safeguarding medicinal plant species and their habitats, conservation efforts support biodiversity and ensure that future generations can continue to benefit from these natural remedies. The utilization of traditional medicinal plants is a well-established field encompassing ethnobotany, pharmacology, and conservation. Traditional medicinal plants have long been used by indigenous communities worldwide to treat various ailments, making them a vital part of cultural heritage and local healthcare systems.

Globally, traditional medicinal plants are integral to healthcare, especially in regions like Asia, Africa, and South America, where they are often the primary healthcare resources for many communities. Research has increasingly focused on the pharmacological potential of these plants, revealing bioactive compounds that could lead to new drug discoveries [52]. Studies have shown that many traditional remedies contain compounds with significant therapeutic properties, supporting their use in traditional medicine and modern pharmaceuticals [40]. Ethiopia is known for its rich biodiversity and extensive use of traditional medicine. Ethnobotanical research in Ethiopia has documented numerous plant species used by local communities for medicinal purposes [46]. However, research efforts have predominantly concentrated on more accessible areas, with remote regions like Bori Mountain in the Yem Zone receiving less attention. Ethiopia's varied climate and topography contribute to its rich flora, including a significant number of medicinal plants [111]. The utilization of traditional medicinal plants in Ethiopia is deeply rooted in the cultural and historical practices of the region. Various studies have documented the extensive use of these plants by local communities to treat a range of ailments. For instance, plants such as "Samoa eta" are known for their potential medicinal properties, including anti-inflammatory and antimicrobial effects [46]. Traditional healers, known as "Wogesha", often serve as the primary healthcare providers in rural areas, relying on their extensive knowledge of plant-based remedies [34].

The African continent is renowned for its rich diversity of medicinal plants, which have been utilized for centuries in traditional medicine to treat various ailments. One of the most well-known medicinal plants is Aloe Vera, widely used for its healing and soothing properties, especially in treating skin conditions such as burns, wounds, and eczema [43]. Artemisia annua, or sweet wormwood, is another significant plant, famous for its derivative artemisinin, which is a key anti-malarial compound [48]. The African potato (Hypoxis hemerocallidea) is commonly used to boost the immune system and treat conditions like prostate problems and urinary tract infections [31]. Moringa oleifera, known as the moringa tree, is valued for its nutritional and medicinal properties. It is used to treat malnutrition, inflammation, and various infections due to its high content of vitamins, minerals, and antioxidants [94]. Sutherland a frutescens, often called the cancer bush, is used for its reputed benefits in treating cancer, diabetes, and stress-related conditions [27]. The Baobab tree (Adansonia digitata), referred to as the "tree of life", is utilized for its fruit, leaves, and bark, which have applications in treating infections, fever, and digestive issues [33].

These plants are integral to the health systems in many African communities, providing accessible and affordable healthcare options. They also represent a potential source of new pharmaceuticals, as their traditional uses inspire modern scientific research into their therapeutic compounds and mechanisms. The continued study and conservation of these medicinal plants are essential for sustaining traditional knowledge and advancing global health.

Traditional herbal medicine refers to the use of plants and their extracts to treat various ailments, a practice deeply rooted in the cultural and historical contexts of different societies. This form of medicine predates written history, with archaeological evidence suggesting the use of medicinal plants as far back as 60,000 years ago [93]. Traditional systems such as Ayurveda, Traditional Chinese Medicine (TCM), and Indigenous African Medicine have developed complex and sophisticated knowledge of herbal remedies. In Ayurveda, for instance, plants like turmeric (Curcuma longa) and ashwagandha (Withania somnifera) are used for their anti-inflammatory and adaptogenic properties [89]. TCM utilizes herbs like ginseng (Panax ginseng) and ephedra (Ephedra sinica) for their energizing and respiratory benefits. African traditional medicine often employs plants such as the African potato (Hypoxis hemerocallidea) and the moringa tree (Moringa oleifera) for their wide-ranging therapeutic effects [104]. These traditional practices are not just historical relics but continue to be integral to healthcare in many parts of the world, especially in developing countries. The World Health Organization estimates that up to 80% of the population in some African and Asian countries depends on traditional medicine for primary healthcare [107]. Modern research has validated many traditional uses of herbal medicine. For example, the anti-malarial drug artemisinin was derived from sweet wormwood (Artemisia annua), a plant long used in Chinese herbal medicine [39]. The efficacy of traditional herbal remedies is increasingly supported by scientific research, highlighting the importance of integrating traditional knowledge with modern medicine to improve health outcomes globally Medicinal plants have been a cornerstone in the discovery of drugs, providing a rich source of bioactive

compounds that have been developed into modern pharmaceuticals. Historically, many drugs were derived from plant sources, and this trend continues as researchers explore traditional remedies for new therapeutic agents. For instance, the discovery of the anti-malarial drug artemisinin from Artemisia annua revolutionised malaria treatment and earned its discoverer, Tu Youyou, a Nobel Prize in Medicine [62]. Another significant example is the development of aspirin from salicin, a compound found in willow bark (Salix spp.), which has been used for pain relief for centuries [105]. Medicinal plants also play a crucial role in cancer treatment.

The alkaloid compounds vincristine and vinblastine, derived from the Madagascar periwinkle (Catharanthus roseus), are essential chemotherapeutic agents used to treat various types of cancer, including leukaemia and Hodgkin's lymphoma [75]. Similarly, the discovery of paclitaxel from the Pacific yew tree (Taxus brevifolia) has been a breakthrough in treating ovarian, breast, and lung cancers [73]. Furthermore, the cardiovascular drug digitalis, obtained from the foxglove plant (Digitalis purpurea), has been used to treat heart conditions for over two centuries [61]. Modern research continues to validate the efficacy of traditional herbal remedies, leading to the isolation of new drug compounds. The vast biodiversity of medicinal plants presents an invaluable repository for drug discovery, necessitating ongoing ethnobotanical research and conservation efforts to protect these natural resources. The integration of traditional knowledge with advanced scientific methods enhances the drug discovery process, highlighting the potential of medicinal plants to address contemporary health challenges and contribute to the development of new therapeutic agents.

2.4. Traditional Medicinal Plant Economic Valuation

Traditional medicinal plant economic valuation refers to the process of assigning monetary values to the various benefits and services provided by traditional medicinal plant resources [24]. This approach aims to understand the true worth of these natural resources and promote their sustainable management. The economic valuation of traditional medicinal plants can be assessed through several methods, including Direct use value: This represents the value derived from the direct utilization of medicinal plants, such as for primary healthcare, income generation, and subsistence purposes. Studies have shown that the collection, processing, and sale of medicinal plant products can provide significant income for rural communities in Ethiopia [47]. Indirect use value: This encompasses the value of ecosystem services provided by medicinal plant habitats, such as water regulation, soil conservation, and biodiversity conservation. The preservation of medicinal plant-rich ecosystems can have indirect economic benefits for local communities [8]. Optional value: This represents the value placed on the potential future use of medicinal plants, either for their own sake or for the development of new pharmaceuticals. As many medicinal plant species

remain unexplored, there is a significant option value associated with their conservation [58]. Existence value: This refers to the value placed on the mere existence of medicinal plant species, regardless of their current or future use. This non-use value can be considered an important component of the total economic value of traditional medicinal plant resources [15]. The economic valuation of traditional medicinal plants can provide valuable information for policymakers, resource managers, and local communities to make informed decisions regarding the sustainable use and conservation of these natural resources [47]. It can also help justify the allocation of resources for the protection and management of medicinal plant-rich ecosystems and develop appropriate economic incentives for their sustainable utilization. The economic valuation of traditional medicinal plants underscores their potential contribution to local economies. Studies have indicated that the trade of medicinal plants can provide significant income for rural households. For example, medicinal plant markets in Ethiopia contribute to the livelihoods of many families, offering an alternative source of income [63]. Additionally, the potential for drug discovery and development from these plants presents opportunities for both local and global pharmaceutical industries. The economic benefits, however, must be balanced with sustainable harvesting practices to ensure the long-term viability of these resources [13].

2.4.1. Global Market Values of Medical Plants

The global market for medicinal plants has seen substantial growth driven by increasing consumer demand for natural and herbal remedies, coupled with advancements in scientific research validating their therapeutic properties. The market encompasses a wide range of products, including herbal medicines, botanical extracts, essential oils, and dietary supplements, valued for their purported health benefits and cultural significance. According to a report by Market Research Future, the global market for herbal medicine is projected to reach USD 111 billion by 2023, reflecting a growing preference for plant-based treatments [79]. Key factors driving this growth include the rising prevalence of chronic diseases, consumer awareness about the adverse effects of synthetic drugs, and the perceived safety and efficacy of herbal remedies. Major players in the pharmaceutical and healthcare industries are increasingly investing in the research and development of plant-derived medicines, aiming to capitalize on the vast biodiversity of medicinal plants found across the globe. Asia-Pacific holds a significant share in the global medicinal plants market, owing to the rich traditional knowledge systems in countries like China and India, where herbal medicine has been practiced for millennia. North America and Europe are also prominent markets, driven by a growing trend toward natural and organic products. However, the commercialization of medicinal plants raises concerns about sustainability, biodiversity conservation, and ethical sourcing practices. Efforts are underway to promote sustainable cultivation, wild-harvesting guidelines, and fair-trade practices to ensure the long-term viability of medic-

inal plant resources while supporting local communities dependent on these natural products.

2.4.2. Marketability of Medicinal Plants in Ethiopia

Understanding the marketability of medicinal plants in Ethiopia involves examining both local and global perspectives. In Ethiopia, medicinal plants play a significant role in traditional medicine systems, catering to a large proportion of the population, particularly in rural areas where access to modern healthcare may be limited. The market for medicinal plants in Ethiopia is influenced by factors such as cultural practices, availability of plant species, demand from local communities, and commercial exploitation for national and international markets [17]. Local markets in Ethiopia thrive on the trade of medicinal plants used in traditional healing practices. Plants like Catha edulis (khat), Ocimum lamiifolium (teffo), and Aloe vera are commonly traded for their medicinal properties, addressing a wide range of health issues, including digestive disorders, skin ailments, and respiratory infections. The demand for these plants is sustained by cultural beliefs, affordability, and perceived effectiveness in treating ailments. On a global scale, Ethiopia's biodiversity makes it a potential hotspot for bioprospecting and pharmaceutical research. Plants such as Catharanthus roseus (Madagascar periwinkle) and Ricinus communis (castor bean) have garnered international attention for their medicinal compounds used in modern pharmaceuticals [10]. However, the sustainable harvesting and management of these plants are critical to prevent overexploitation and ensure their long-term availability. Efforts to promote sustainable practices and value addition in the medicinal plant sector are underway in Ethiopia. Initiatives focus on cultivation, processing, and certification to meet international standards, enhancing market access and supporting rural livelihoods [3]. Regulatory frameworks and policies are also evolving to manage the trade of medicinal plants, ensuring fair benefit-sharing and conservation of biodiversity [83]. While the market for medicinal plants in Ethiopia is diverse and culturally entrenched, sustainable management practices and strategic interventions are essential to harness their economic potential while preserving biodiversity and traditional knowledge.

2.4.3. Threats to Indigenous Knowledge of Traditional Medicinal Plants

The preservation of indigenous knowledge surrounding traditional medicinal plants faces numerous threats in today's globalized world. One of the primary challenges is the loss of biodiversity due to habitat destruction, climate change, and unsustainable harvesting practices. Many medicinal plants are found in fragile ecosystems that are increasingly vulnerable to deforestation, urbanization, and agricultural expansion, leading to the depletion of plant populations essential for traditional medicine [82]. Additionally, cultural erosion and demographic changes contribute to the gradual loss of tradi-

tional knowledge transmission. Younger generations often migrate to urban areas, where traditional practices may be less valued or forgotten, disrupting the intergenerational transfer of medicinal plant knowledge [52]. The commercialization and commoditization of traditional medicinal plants pose another significant threat. As global demand for herbal medicines grows, there is a risk of overexploitation and unsustainable harvesting practices driven by profit motives rather than sustainable resource management [88]. This can lead to the loss of biodiversity and cultural significance associated with these plants, undermining their long-term availability and efficacy in healthcare systems. Efforts to mitigate these threats include promoting sustainable harvesting practices, establishing protected areas for medicinal plants, and supporting community-led conservation initiatives that integrate traditional ecological knowledge [102]. Strengthening intellectual property rights and ensuring fair benefit-sharing agreements with indigenous communities are also crucial for safeguarding traditional knowledge and fostering ethical partnerships in bioprospecting and drug discovery. The issue of intellectual property rights (IPR) related to traditional medicinal plants is complex and often contentious, revolving around questions of ownership, benefit-sharing, and cultural heritage. Traditional knowledge associated with medicinal plants, accumulated over generations by indigenous and local communities, has been exploited without adequate recognition or compensation. This exploitation ranges from bioprospecting for active compounds to the commercialization of herbal remedies without consent or benefit-sharing agreements with the communities that hold this knowledge [84]. Efforts to address these issues have led to the development of legal frameworks and international agreements aimed at protecting traditional knowledge and ensuring fair and equitable benefit-sharing. For example, the Nagoya Protocol, adopted under the Convention on Biological Diversity, establishes guidelines for access to genetic resources and the fair and equitable sharing of benefits arising from their utilization [21]. Similarly, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) recognizes the rights of farmers and indigenous communities over their traditional knowledge and resources. National governments have also implemented measures to protect traditional knowledge through patents, trademarks, and geographical indications. For instance, India has established a Traditional Knowledge Digital Library (TKDL) to prevent the misappropriation of traditional knowledge related to medicinal plants like neem (Azadirachta indica) and turmeric [26]. These initiatives aim to balance the promotion of innovation and commercialization with the rights of indigenous communities to control and benefit from their traditional knowledge. Despite these efforts, challenges remain in implementing and enforcing IPR protections effectively, particularly in developing countries where governance and legal systems may be inadequate. Strengthening these frameworks, enhancing community participation, and fostering dialogue between stakeholders are

essential to safeguarding traditional medicinal plant knowledge for future generations.

2.5. Traditional Medicinal Plant Conservation

Traditional medicinal plant conservation refers to the strategies and practices aimed at preserving plant species used in traditional medicine to ensure their sustainable availability for future generations. This involves protecting the natural habitats of these plants, promoting sustainable harvesting practices, and safeguarding the traditional knowledge associated with their use. Conservation efforts are critical not only for maintaining biodiversity but also for preserving cultural heritage and supporting sustainable livelihoods [32].

Traditional medicinal plants are invaluable resources for healthcare, particularly in rural and indigenous communities. They form the basis of modern pharmaceuticals and contribute significantly to the global economy. However, these plants are increasingly threatened by overharvesting, habitat destruction, and climate change. Effective conservation ensures that these valuable resources remain available for future generations and that traditional knowledge is preserved. Several methods are employed in the conservation of traditional medicinal plants. In situ conservation focusses on protecting medicinal plants in their natural habitats through the establishment of protected areas such as national parks and nature reserves. This approach maintains the ecological balance and genetic diversity of the plants [60]. Ex situ conservation involves preserving plant species outside their natural habitats through botanical gardens, seed banks, and conservation facilities. This method is particularly useful for endangered species that cannot be adequately protected in the wild [21]. Additionally, sustainable harvesting practices are implemented to allow for the continued use of medicinal plants without depleting their populations. This includes rotational harvesting, selective harvesting, and community-based management plans [107]. Documentation and preservation of traditional knowledge are also vital components of conservation efforts. Recording the traditional uses and preparation methods of medicinal plants ensures that this knowledge is not lost. This can involve ethnobotanical studies, community workshops, and digital databases [64]. However, conservation efforts face several challenges, including habitat destruction caused by deforestation, urbanization, and agricultural expansion. Overharvesting and unsustainable harvesting practices can quickly deplete plant populations, especially those that are slow-growing or have specific habitat requirements. Climate change also poses a significant threat, as alterations in climate patterns can affect the distribution and survival of medicinal plant species, making conservation efforts more complex. Intellectual property rights present another challenge, ensuring that the benefits of conservation and commercialization are shared equitably with the communities that have traditionally used these plants. Addressing these challenges requires a multifaceted approach that in-

volves collaboration among governments, local communities, and international organizations to create and enforce policies that support sustainable conservation practices. Conservation of Traditional Medical Plants Despite their importance, traditional medicinal plants face significant conservation challenges. Deforestation, agricultural expansion, and overharvesting pose serious threats to the biodiversity of regions like Bori Mountain. The loss of habitat endangers not only plant species but also the traditional knowledge associated with their use [7]. Efforts to conserve these plants involve both in situ and ex situ strategies. In situ conservation focuses on protecting plants within their natural habitats, while ex situ conservation involves cultivating plants in botanical gardens and seed banks [14].

2.5.1. Threat to MPs and Their Conservation Strategies

Medicinal plants (MPs) face significant threats globally, primarily due to habitat destruction, overharvesting, climate change, and unsustainable harvesting practices. Habitat loss, driven by deforestation, urbanization, and agricultural expansion, disrupts ecosystems and threatens the natural habitats of many medicinal plant species [112]. Overharvesting for commercial purposes, often exacerbated by high global demand for herbal medicines, depletes wild populations and can lead to local extinctions [101]. Climate change further exacerbates these threats by altering temperature and precipitation patterns, affecting the distribution and availability of medicinal plant species [103]. Conservation strategies to mitigate these threats include establishing protected areas, promoting sustainable harvesting practices, and fostering community-based conservation initiatives. Protected areas such as national parks and botanical reserves help safeguard critical habitats and biodiversity hotspots where medicinal plants thrive [92]. Sustainable harvesting practices, guided by scientific research and traditional ecological knowledge, aim to ensure that plant populations can regenerate and continue to provide resources for future generations [28]. Community-based conservation initiatives empower local communities to manage and protect their natural resources, promoting sustainable livelihoods and cultural practices while conserving biodiversity [77]. Furthermore, international agreements and policies play a crucial role in supporting conservation efforts. The Convention on Biological Diversity (CBD) promotes the conservation and sustainable use of biodiversity, including medicinal plants, through measures such as the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits [28]. These frameworks emphasize the importance of equitable benefit-sharing, ensuring that local communities derive fair compensation from the commercial use of traditional knowledge and genetic resources. Despite these efforts, effective conservation of medicinal plants requires continued collaboration among governments, researchers, local communities, and stakeholders to address underlying drivers of biodiversity loss and

ensure the sustainable management of natural resources for future generations [37].

2.5.2. Conservation Strategies of MPs

Conservation strategies of MPs Conserving medicinal plants (MPs) is crucial for maintaining biodiversity, preserving cultural heritage, and sustaining global health needs. Several conservation strategies are employed to address the threats facing MPs, such as habitat loss, overharvesting, climate change, and unsustainable harvesting practices. Protected areas, including national parks and reserves, play a vital role by providing safe havens for MPs and their habitats, ensuring their long-term survival [65]. Sustainable harvesting practices are promoted through guidelines that balance traditional knowledge with ecological sustainability, allowing populations to regenerate naturally [102]. Cultivation efforts are also encouraged to reduce pressure on wild populations and support local livelihoods [55]. Engaging local communities through participatory conservation approaches fosters stewardship and enhances the socio-economic benefits derived from MPs [88]. Furthermore, robust research, monitoring, and policy frameworks are essential to inform and enforce effective conservation measures, ensuring that medicinal plants continue to provide valuable resources for future generations.

2.5.3. The Role of TMPs in Maintaining Human Health in Ethiopia

Traditional medicinal plants (TMPs) play a crucial role in maintaining human health in Ethiopia, where they are deeply embedded in cultural practices and traditional healthcare systems. Ethiopia's diverse ecological zones, ranging from highlands to lowlands, host a wealth of medicinal plant species that have been used for centuries by various ethnic communities to treat a wide array of health conditions. TMPs are often the primary source of healthcare in rural areas where access to modern medicine is limited or where cultural preferences favour traditional remedies [42]. These plants are valued for their effectiveness, accessibility, and affordability, making them accessible to a significant portion of the population. Studies have documented extensive traditional knowledge regarding the use of TMPs for ailments such as malaria, respiratory infections, gastrointestinal disorders, and skin diseases [46]. For instance, plants like the Aloe vera, Ruta chalepensis, and Carissa spinarum are commonly used in traditional medicine for their therapeutic properties. The role of TMPs extends beyond their medicinal benefits to encompass socio-economic aspects as well. Many Ethiopians derive livelihoods from the cultivation, harvesting, and trade of medicinal plants, contributing to local economies and sustaining traditional healing practices [17]. Despite the increasing availability of modern healthcare facilities in urban centers, TMPs continue to be integrated into healthcare practices, reflecting their cultural significance and perceived ef-

ficacy. Efforts to document and validate the medicinal properties of TMPs through ethnobotanical research contribute to their preservation and integration into national healthcare policies. Integrating TMPs into formal healthcare systems could enhance healthcare access and affordability, particularly in rural and underserved communities [59]. However, sustainable harvesting practices and conservation efforts are crucial to ensure the long-term availability of medicinal plants and to safeguard biodiversity.

2.5.4. Ethnoveterinary Medicinal Plant Use in Ethiopia

Ethnoveterinary medicinal plant use in Ethiopia represents an integral part of traditional animal healthcare practices, deeply rooted in local knowledge systems and cultural heritage. Across Ethiopia's diverse agro-ecological zones, various ethnic communities rely on medicinal plants to treat livestock ailments, ensuring the health and productivity of their animals. The use of ethnoveterinary medicinal plants (EVMPs) reflects a holistic approach to animal health management, addressing a wide range of conditions, including digestive disorders, respiratory infections, parasitic infestations, and wounds [46, 44]. Ethnoveterinary knowledge is typically transmitted orally from generation to generation, with specific plants identified based on observed symptoms and traditional practices. Plants such as Aloe vera, Calpurnia aurea, Olea europaea, and Justicia schimperiana are commonly used in various forms such as decoctions, infusions, poultices, and topical applications [97]. These plants are valued not only for their therapeutic efficacy but also for their accessibility and affordability, particularly in rural areas where modern veterinary services may be limited or costly. Despite the importance of EVMPs, their sustainability and conservation face challenges such as overharvesting, habitat loss, and insufficient documentation of traditional knowledge. Efforts to promote sustainable use and conservation of ethnoveterinary plants are emerging, supported by research initiatives that document their efficacy and potential for integration into formal veterinary healthcare systems [110]. Integrating ethnoveterinary practices with modern veterinary medicine holds promise for enhancing animal health outcomes while preserving Ethiopia's biodiversity and traditional knowledge systems.

2.6. Threats to TMPK and Medicinal Plant Species in Ethiopia

Threats to TMPK and medicinal plant species in Ethiopia Understanding the threats to traditional medicinal plant knowledge (TMPK) and medicinal plant species in Ethiopia reveals challenges that jeopardise both biodiversity conservation and cultural heritage. Ethiopia's diverse ecosystems host numerous medicinal plants integral to traditional medicine and local livelihoods. However, these plants face significant threats, primarily driven by unsustainable harvesting practices, habitat degradation, deforestation, and climate

change [44]. Unregulated harvesting, often for commercial purposes, leads to the overexploitation of medicinal plant species. This threatens their natural populations and compromises their sustainability, impacting local communities dependent on these resources for healthcare and income generation [46]. Additionally, habitat loss due to agricultural expansion, urbanization, and land degradation further reduces the availability of medicinal plants in their natural habitats [50]. Climate change poses another significant threat by altering the distribution and availability of medicinal plants, affecting their growth patterns and medicinal properties. Changes in temperature, rainfall patterns, and extreme weather events can disrupt plant phenology and regeneration cycles, making it challenging for species to adapt and survive [9]. Efforts to mitigate these threats include promoting sustainable harvesting practices, establishing protected areas, and integrating traditional knowledge into biodiversity conservation strategies. Community-based conservation initiatives empower local communities to manage medicinal plant resources while benefiting from their cultural and economic value [71]. Research and documentation of TMPK are essential for understanding the dynamics of plant use and ensuring the conservation of Ethiopia's rich medicinal plant biodiversity for future generations.

Conservation of Medicinal Plants of Ethiopia

Conservation of medicinal plants in Ethiopia is a critical endeavor aimed at preserving biodiversity, supporting sustainable livelihoods, and maintaining cultural traditions associated with traditional medicine. Ethiopia boasts a rich diversity of medicinal plants used for centuries by various ethnic communities to address health needs. However, these plants face numerous threats, such as habitat loss, overharvesting, climate change, and unsustainable harvesting practices, which jeopardize their survival and availability [25]. Efforts to conserve medicinal plants in Ethiopia include the establishment of protected areas and conservation initiatives that integrate traditional knowledge with modern scientific approaches. Protected areas such as national parks and reserves serve as refuges for threatened species, safeguarding their habitats and promoting sustainable use practices [68]. Community-based conservation strategies empower local communities to manage and benefit from medicinal plant resources responsibly while preserving cultural practices and biodiversity [97]. Research plays a pivotal role in conservation efforts by documenting traditional knowledge, identifying species at risk, and assessing their ecological and socio-economic importance [47]. Initiatives to promote the cultivation and sustainable harvesting of medicinal plants not only reduce pressure on wild populations but also support income generation and healthcare provision in rural areas [1]. Policy frameworks and regulatory measures are essential for effective conservation, ensuring that medicinal plants are sustainably managed and that benefits are equitably shared among stakeholders [36]. Integrating traditional medicine into national healthcare systems can enhance the recognition and preservation of Ethiopia's medicinal plant heritage while contributing to public health initiatives and sustainable development goals.

2.7. Research Gaps

Traditional Medicinal Plant Utilization, Conservation, and Economic Biodiversity: Ethiopia's diverse climates and landscapes result in a rich variety of flora, with many species having medicinal uses. Traditional medicine is widely practiced in Ethiopia, particularly in rural areas where access to modern healthcare is limited. Ethnobotanical surveys have identified several medicinal plants and their uses [97]. Traditional medicine remains a key healthcare resource in Ethiopia, with many plants being used to treat common ailments. The use of traditional medicine is deeply embedded in the culture and daily life of Ethiopian communities. Pharmacological Studies: Some Ethiopian medicinal plants have been analyzed for their chemical composition and pharmacological effects, leading to the identification of bioactive compounds with therapeutic potential [34]. One of the critical challenges in the utilization, conservation, and economic valuation of traditional medicinal plants is the lack of comprehensive documentation and scientific validation of their medicinal properties. Ethnobotanical studies are essential for cataloguing the various species and their uses, which can then inform conservation strategies and sustainable utilization [18]. Furthermore, integrating traditional knowledge with modern scientific research can enhance the understanding and efficacy of plant-based medicines [12]. Despite the extensive documentation of medicinal plants in Ethiopia, detailed studies on the medicinal flora of Bori Mountain are lacking. There is a need for comprehensive ethnobotanical surveys and pharmacological studies in this area to document specific medicinal plants and their uses. Secondly, the conservation status of medicinal plants in the Yem district of Bori Mountain is not well documented. Understanding the threats to these plants and their habitats is crucial for developing effective conservation strategies. Thirdly, there is limited information on the economic value of traditional medicinal plants in the Yem district of Bori Mountain. Assessing their economic impact can highlight their importance to local communities and support sustainable utilization. To fill the knowledge gap regarding the specific medicinal flora of Bori Mountain, comprehensive ethnobotanical surveys should be conducted. These surveys will document medicinal plants, their uses, and traditional knowledge from local healers and community members. Ethnobotanical methods involve structured interviews, participant observation, and the collection of plant specimens [68]. Such surveys are essential for understanding the local utilization of medicinal plants and preserving traditional knowledge. Phytochemical Analysis: To validate the traditional uses of medicinal plants and discover new medicinal compounds, phytochemical analysis is crucial. This involves the extraction and characterization of chemical com-

pounds in identified medicinal plants. Techniques such as chromatography and spectroscopy can be used to identify bioactive compounds with potential therapeutic effects [41]. Conservation Assessments: Evaluating the conservation status of medicinal plants in Bori Mountain through field studies and threat assessments is necessary. This will involve identifying endangered species, understanding the factors threatening their survival, and developing conservation strategies. Conservation assessments can be guided by the IUCN Red List Categories and Criteria, which provide a standardized approach to evaluating the extinction risk of species [54]. Conducting economic valuation studies will assess the financial impact of medicinal plants on local communities. This includes evaluating the potential for sustainable harvesting, cultivation, and commercialization of these plants. Economic valuation methods can help quantify the economic benefits of

medicinal plants and support arguments for their conservation and sustainable use [80]. Interdisciplinary collaboration, collaborating with experts in botany, pharmacology, conservation, and economics, ensures a comprehensive approach to studying traditional medicinal plants. This interdisciplinary effort provides a robust methodological and scientific foundation for the study. By integrating various scientific disciplines, the study can address the complexities of traditional medicinal plant utilization, conservation, and economic valuation [95]. By addressing these knowledge gaps and employing rigorous methodologies, this study aims to contribute significantly to the understanding, conservation, and sustainable use of traditional medicinal plants in Bori Mountain. This will benefit local communities and provide valuable insights for the broader scientific community.

2.8. Conceptual Framework

Table 1. Conceptual Framework.

Component	Description	Relationship to Other Components
Traditional Knowledge & Practices	Plant identification (local names) - Medicinal uses and preparation - Harvesting practices - Knowledge transmission within Yem community	Guides utilize practices and influences conservation efforts
Medicinal Plant Diversity	*- Inventory of medicinal plant species - Abundance and distribution patterns - Ecological threats and conservation needs*	*- Provides resource base for utilization and economic value*
Economic Value	*- Subsistence use for healthcare - Market dynamics and trade - Income generation and economic contribution*	*- Can incentivize sustainable use or overexploitation*
Institutional Framework	*- Policies and regulations - Role of local institutions and governance - Enforcement mechanisms for sustainable utilization*	*- Crucial for balancing utilization and conservation*
Conservation Strategies	*- Community-based initiatives - Habitat protection and restoration - Cultivation and propagation of plants - Integration of traditional knowledge*	*- Relies on traditional knowledge and addresses economic considerations*

3. Significance of the Study

This study delves into the critical and interconnected issues of conservation, utilization, and economic valuation of Samoa eta medicinal plants in the Bori Mountain. Its findings have the potential to significantly impact various stakeholders and contribute to positive outcomes in several key areas:..\BORI picture.

3.1. Conservation Strategies

Data-driven insights: The study will identify and document the diversity of Samoa eta medicinal plants in the Bori Mountain, forming a crucial baseline for future conservation

efforts.

Threat assessment: By investigating ecological threats (unsustainable harvesting, habitat loss, climate change) and their impact on specific species, the study can inform targeted conservation strategies. Community engagement: Integrating the knowledge and perspectives of the Yem community through participatory methodologies can lead to more effective and sustainable conservation practices.

3.2. Sustainable Utilizations

Documentation of traditional knowledge: Recording and analyzing traditional knowledge on medicinal plant use will promote understanding and appreciation of their cultural significance. Promoting sustainable practices: Evaluating

current harvesting and cultivation methods and proposing improvements can ensure the long-term availability of these resources.

Exploring cultivation potential: Investigating the feasibility and economic viability of cultivating high-demand medicinal plants can provide alternative income sources and reduce pressure on wild populations.

3.3. Livelihood Improvement

Quantifying the economic value of medicinal plants and exploring market opportunities can empower the Yem community through sustainable income generation. Empowerment and self-reliance: Enhancing knowledge and skills related to sustainable utilizations can increase local capacity and autonomy in managing this valuable resource. Cultural heritage preservation: safeguarding traditional medicinal knowledge and practices strengthens the cultural identity and well-being of the Yem community.

3.4. Policy Development

Evidence-based recommendations: The study's findings can inform policy decisions on medicinal plant conservation, sustainable utilizations, and equitable benefit-sharing mechanisms. Supporting existing frameworks: The research can contribute to national and regional policies related to biodiversity conservation, traditional knowledge protection, and community development [84]. Promoting informed decision-making: The data and insights generated can guide stakeholders in crafting policies that balance conservation, economic development, and community well-being. This study's significance extends beyond the Bori Mountain, contributing to broader conversations and efforts surrounding Sustainable resource management, highlighting the importance of balancing utilization with conservation for long-term benefits.

Community-based conservation: demonstrating the value of integrating local knowledge and participation in conservation strategies. Biodiversity conservation in Ethiopia: Contributing to the national efforts to protect and maintain unique ecosystems and their resources. This study can gain valuable knowledge and contribute to a future where the Bori Mountain's medicinal plant wealth is conserved, sustainably utilized, and continues to benefit the Yem community and the wider region.

4. Research Questions and Objectives

4.1. Research Questions

Based on the general objective of the study, some potential research questions can guide the investigation:

1. What is the diversity of medicinal plant species present in the Bori Mountain, and how are they classified and named by the Yem community?
2. What are the ecological status and distribution patterns of Samoa eta medicinal plants in the study area?
3. What is the economic value of medicinal plants in the study area, and what are the market dynamics and trade patterns associated with medicinal plant products?
4. What are the existing policies, regulations, and institutional frameworks related to the conservation and sustainable utilization of medicinal plants in the study area?
5. How can medicinal plant conservation and sustainable utilization be integrated into local development plans in the study area?

4.2. Objectives

4.2.1. General Objective

To assess and promote the sustainable conservation, utilization, and economic valuation of Samoa eta medicinal plants in the Bori Mountain Yem Zone Central Ethiopia Regional State.

4.2.2. Specific Objectives

1. To identify and document the diversity of medicinal plant species in the Bori Mountain area of the Yem district.
2. To assess the ecological status and distribution patterns of Samoa eta medicinal plants in the study area.
3. To determine their conservation needs and prioritize species for conservation efforts.
4. To evaluate the potential economic value of Samoa eta medicinal plants in the study area by conducting market surveys, analyzing trade data, and assessing the income generated from the sale of medicinal plant products.
5. To analyze the existing policies, regulations, and institutional frameworks related to the conservation and sustainable utilization of Samoa eta medicinal plants in the Yem district, Central Ethiopia Regional State, and provide recommendations for their improvement.

5. Material and Methods

5.1. Description of the Study Area

Figure 1. Study Area.

5.1.1. Location

The location information details the geographic coordinates, which range from latitude 7°37'N to 8°02'N and longitude 37°40'E to 37°61'E. It is situated approximately 297 km southwest of Addis Ababa, covering a land surface area of 724.5 sq. km [98]. The topography is characterized by rolling mountains, long gorges of the Gibe River, steep slopes, and flat to undulating plateaus, with an elevation range between 920 and 2939 meters above sea level [57].

In terms of administrative divisions, the area consists of 34 rural sub-districts, 3 woredas, and 6 towns. The total popula-

tion is 122,419. with males constituting 61,576 (50.3%) and females 60,842 (49.7%), leading to a population density of 169 persons per sq. km (Syariah & CSA, 2013). The ethnic composition includes 91.87% Yem people, 5.6% Oromos, 0.82% Hadiyas, and 1.71% other ethnic groups. The primary languages spoken are Yemsa (79.05%), Oromiffa (19.24%), and other languages (1.71%). Religious affiliation predominantly comprises Orthodox Christianity (71.24%), Islam (25.14%), and Protestants (3.48%) [30].

The livestock population totals 236,102, including 87,716 cattle, 42,585 sheep, 50,169 goats, 3,868 horses, 4,896 donkeys, 654 mules, and 46,214 poultry [46]. The mean annual rainfall ranges from 900 to 2200 mm, primarily occurring from June to September. Agroclimatic zones include 18.4% Dega (Cool Highlands), 57.6% Weyna Dega (Midlands), and 24.0% Kolla (Lowlands). The high rainfall period extends from May to September, peaking in July with 256 mm, while the low rainfall period from November to February sees December recording the lowest amount at 25 mm over a span of 13 years (2000-2012). The mean annual temperature ranges from a high of 21 ℃ in May to a low of 7 ℃ in December during the same period. The predominant soil types are aluvisols, followed by eutric nitosol, leptosol, luvisol, and vertisol [74].

5.1.2. Economic Activity

Agriculture, which includes crop cultivation and livestock rearing, is the main economic activity in the district. Rain-fed agriculture is the mainstay of the district, the dominant crops being cereals such as wheat (Triticum aestivum), barley (Hordeum vulgare), teff (Eragrostis tef), maize (Zea mays), sorghum (Sorghum bicolor) (Moench), pulses, and root crops such as „ewa" (Ensete ventricosum), „mareduna"/Plecthranthus edulis, and „aju"/Coccinia abyssinica [43]. Subsistence agriculture is practiced in the district based on cereal, which is the staple food. Important cash crops include teff, wheat, barley, pulses, chat, animal products (mainly butter), and remittances.

5.1.3. Vegetation

The landscape of the Yem Zone is covered by 14,916 hectares of annual crops, 35,851 hectares of permanent crops, and 7,463 hectares of natural forest fragments, among others [20]. The district has a rugged, irregularly rolling topography. It was observed that Yem has a small number of woodlands and protected remnant natural forests. The protected natural forests include Kumuli Forest [109]. Aanebari Kelo and Oya forests. Moreover, private many farmlands traditionally have an agroforestry nature with mature stands of indigenous tree species that seem deliberately left, such as Albizia schimperiana, Apodytes dimidiata, Croton macrostachyus, Ficus sycomorus, F. sur, F. vasta, Juniperus procera, Olea capensis subsp. macrocarpa, Podocarpus falcatus, Prunus africana, and Syzygium guineense subsp. guineense. The vegetation of the

Yem area includes dry evergreen Afromontane in the high-altitude areas that reach the highest peak at Bori Mt. (2939 m a.s.l.) while wooded grassland with deciduous Combretum-Terminalia types along the Gibe River valley, which descends lower up to 1400 m a.s.l.

5.2. Study Design

The study follows a mixed-method research design, combining both qualitative and quantitative approaches. It aims to investigate the utilization, conservation, and economic valuation of traditional medicinal plants.

5.3. Target Population

The target population for this study comprises communities and individuals involved in traditional medicinal plant practices. This includes a specific population of 122,419 individuals, encompassing local communities, herbal practitioners, traditional healers, and relevant stakeholders within regions known for their rich biodiversity and traditional medicinal plant practices.

5.4. Sample and Sampling Procedures

5.4.1. Sampling Method

A stratified random sampling method will be employed to ensure adequate representation of different ecological zones and socio-cultural groups within the Yem Zone, considering its diverse ecosystems and communities. The Bori Mountain will be stratified based on vegetation types (e.g., dry evergreen Afromontane forests at higher elevations and wooded grasslands with deciduous trees along river valleys at lower altitudes) and ethnic communities.

Sampling Units

Vegetation Plots: Randomly selected plots within different vegetation types will be established for botanical surveys to document medicinal plant species richness and abundance.

Household Surveys: Randomly selected households within each stratum will be surveyed to gather information on medicinal plant use, traditional knowledge, and socio-economic factors related to utilization and valuation.

Market Surveys: Local markets and trading centers within the study area will be sampled to assess the trade and economic value of medicinal plants.

Sampling Procedure

Stratification: Divide the Yem Zone into strata based on ecological and socio-cultural characteristics.

Random Selection: Randomly select sampling units within each stratum using a random number generator or systematic random sampling.

5.4.2. Sample Size Determination

The sample size for ethnobotanical surveys will be deter-

mined using [96] to ensure statistical validity.

$$n = \frac{Z^2 pq}{e^2}$$

Where:

n = sample size

Z = Z-value (1.96 for a 95% confidence level)

p = estimated proportion of an attribute present in the population (0.5 for maximum variability).

q = 1 - p

e = desired level of precision (0.05)

Assuming a total population of 122,419 in the Yem Zone and considering a 95% confidence level and a 5% margin of error, the minimum sample size for the ethnobotanical interviews will be:

n = (1.96) ²* 0.5 (1-0.5) / (0.05). 2 = 384 respondents

To account for potential non-response or incomplete data, the sample size will be increased by 10%, resulting in a total sample size of approximately 422 respondents.

5.5. Data Collection Techniques

The study targets a population of 122,419 (females (55,771) and 66,648 males) in the Yem Zone, with a sample size of 384 to 422 heads of households (212 men and 210 women). Participants provide background information, including age, gender, and income, and are asked about their use of traditional medicine. Ten kebele villages and Bori Mountain are selected via purposive sampling to cover typical characteristics and variations in environmental, social, and economic attributes. Additionally, snowball sampling is used to sample specialized herbalists, comprising 5 elders (2 women, 3 men) and 5 younger individuals (2 women, 3 men), to identify commonly used medicinal plants during transect walks. To assess human land use and its negative and positive influences on the availability of traditional herbal medicine, household heads are considered in the survey. Within these villages, households are stratified based on the manner of construction of the houses, which represent different levels of income. Households are selected by stratified random sampling for the household questionnaire survey.

Questionnaires are administered to the household heads since they are known to make important decisions regarding the use of traditional herbal medicine from plants for treating minor illnesses at home. Therefore, they are able to provide adequate information that explains the availability of traditional herbal medicine.

For this research, it is necessary to provide questionnaires in English as well as in Yemisa. Therefore, we relied on the help of 2 native Yemisa speakers for the translation.

Transect walks are carried out throughout the region to determine the biodiversity of medicinal plants. A total of 9 quadrant transects are carried out in Bori Mountain. This is done with the aid of specialized herbalists who help in the identification of the medicinal plant species. During these transect walks, species richness, abundance, habitat of occurrence, and status of the medicinal plants are recorded on a transect data sheet. The abundance of medicinal plants is determined [48].

The abundance is categorized as S = scattered, i.e., scattered, thus needing careful monitoring (three species of medicinal plants in a quadrant); T = threatened, i.e., the species are decreasing in number (two species of medicinal plants in a quadrant); PS = Presently safe, i.e., the species are present but need efforts to protect them (five or more species in a quadrant); D = don't know, i.e., doubtful presence (one species in a quadrant), and V = vulnerable, i.e., easily destroyed [78]. Based on these estimates, the abundance of the medicinal plants is determined. Quadrants are laid out on open vegetation and used to categorize the abundance. A quadrant size of 10 m $\times$ 10 m was laid on open vegetation [91]. The number of medicinal plants in the quadrant and their growth attributes are used to categorize the abundance of the medicinal.

Primary data collection includes semi-structured interviews, focus group discussions, and field surveys to document medicinal plant utilization and conservation. Economic valuation involves market surveys and interviews to gather data on trade dynamics and economic value. Secondly, data collection includes reviewing existing literature, government documents, maps, aerial photographs, and census data.

Ethnobotanical surveys document indigenous knowledge related to plant uses and contribute to biodiversity conservation. Ecological assessments employ field and remote sensing techniques to collect data on vegetation structure and species composition. Economic valuation techniques assess the monetary value of medicinal plants to inform sustainable management and conservation. Data analysis involves statistical methods, spatial analysis, and qualitative analysis to extract meaningful insights.

5.6. Quantitative Analysis of Ethnographic Data

5.6.1. Percentages, Averages, and Ranges

Descriptive statistics such as percentages, averages, and ranges will be calculated to summarize ethnobotanical data.

5.6.2. Preference Ranking

Preference ranking will be used to identify the most valued medicinal plants based on criteria such as effectiveness, availability, and cultural significance.

5.6.3. Direct Matrix Ranking

A direct matrix ranking will be conducted to assess the multiple uses of medicinal plants, considering factors like medicinal, nutritional, and economic benefits.

5.6.4. Informant Consensus Factor (ICF)

The Informant Consensus Factor (ICF) will be calculated to

evaluate the degree of consensus among informants on the use of specific medicinal plants for treating particular ailments. The ICF is calculated using the formula:

$$ICF = \frac{Nur - Nt}{Nur - 1}$$

Where:

Nur == number of use reports for a particular plant use category.

Nt= number of taxa used for that category

5.6.5. Fidelity Level (FL)

Fidelity Level (FL) will be determined to identify the preferred species for treating specific ailments using the formula:

$$FL(\%) = (Np\ N) \times 100$$

Where:

Np == number of informants who mentioned the use of a species for a particularailment.

N = total number of informants

5.6.6. Use Value Index (UV) of Medicinal Plants

The Use Value Index (UV) will be calculated to quantify the relative importance of each medicinal plant using the formula:

$$UV = \frac{\sum Ui}{N}$$

Where:

Ui == number of uses mentioned by each informant for a given species

N = total number of informants

This comprehensive approach to data collection and analysis will provide a robust understanding of the utilization, conservation, and economic valuation of traditional medicinal plants in the study area.

5.7. Materials

For the botanical surveys, we will use GPS devices to accurately record the locations of plant species during field surveys and field notebooks for detailed recording of plant descriptions, habitat conditions, and field observations. Herbarium sheets will be employed for collecting and preserving plant specimens for taxonomic identification and future reference, while digital cameras will be used to photograph plant specimens and habitats. Plant identification guides and keys will aid in identifying the collected plant specimens.

For vegetation sampling and GIS mapping, quadrats and transect lines will be used to establish sampling plots and systematically collect vegetation data. Soil testing kits will analyze soil properties in different habitats, and GIS software (e.g., ArcGIS) will be utilized to map the distribution patterns

and ecological niches of Samoa eta medicinal plants. Measurement tapes will measure plant height, stem diameter, and other morphological features, and labeling supplies will label collected plant specimens and samples.

During ethnobotanical surveys, structured interview guides will facilitate interviews and focus group discussions with traditional healers and community members. Audio recorders will capture these discussions to ensure accurate data collection. Consent forms, prepared in the local language, will be used to obtain informed consent from participants. Notebooks and pens will be essential for taking notes during interviews and discussions.

For market surveys and economic valuation, survey questionnaires will be used to assess demand, prices, and trade volumes of medicinal plant products in local markets. Market price records will document these findings, and economic valuation software (e.g., SPSS, Excel) will analyze the economic data to estimate the value of Samoa eta medicinal plants.

Data storage and analysis will require secure storage facilities for physical data, herbarium specimens, and other collected materials. Computers and software will be necessary for data entry, storage, and analysis, including statistical and qualitative analysis software (e.g., SPSS, R, NVivo). External hard drives and cloud storage will back up digital data, ensuring data security.

5.8. Ethical Considerations

When conducting research involving indigenous communities and traditional knowledge, it is essential to address several ethical issues to ensure respect, fairness, and transparency. The following measures will be taken:

Letter of Cooperation: I shall take a formal letter of cooperation from Jimma University to demonstrate support and commitment to ethical standards. Share this letter with local authorities and community leaders to build trust and facilitate collaboration.

Informed Consent: I shall obtain informed consent from all participants by clearly explaining the purpose of research, methods, risks, benefits, and participant rights. Prepare consent forms in the local language and present them culturally appropriately. Prefer written consent, but document oral consent if literacy is a concern.

Privacy and Confidentiality: I shall strictly protect participants' privacy and confidentiality by anonymizing personal identifiers and securely storing data. I shall limit data access to the research team, using password protection for electronic data and locked storage for physical data.

Fair Sharing of Benefits: I shall ensure fair sharing of research benefits with participating communities by providing accessible research findings and discussing benefit-sharing for any economic gains. I shall conduct capacity-building initiatives, such as training workshops on sustainable harvesting and conservation practices.

Cultural Sensitivity: Conduct research with respect for the cultural practices and beliefs of indigenous communities. Involve traditional healers and community leaders actively in the research process to acknowledge and value their perspectives and knowledge. By addressing these ethical considerations, the research aims to foster a respectful and mutually beneficial relationship with indigenous communities, ensuring their rights and interests are protected throughout the study.

Abbreviations

CBD	Convention on Biodiversity
CERS	Central Ethiopia Regional State
CTSCA	Culture, Tourism, and State Communication Affairs of Districts
EBI	Ethiopian Biodiversity Institute
EVM	Ethno veterinary medicine
EVMPs	Ethio Veterinarian medicinal plants.
FAO	Food and Agriculture Organization of the United Nations
FL	Fidelity Level
GIS	Geographical Information System
IBC	Institute of Biodiversity Conservation
ICF	Informant Consensus Factor
IGAD	Intergovernmental Authority on Development.
ILRI	International Livestock Research Institute
IUCN	International Union for Conservation of Nature
MPs	Medicinal Plant Species
MoA	Ministry of Agriculture
MPK	Medicinal Plant Knowledge
NAMSA	National Metrological Services Agency
NBSAP	National Biodiversity Strategy and Action Plan
PBBMD	Plant Biology and Biodiversity Management Department
TMPs	Traditional Medicinal Plants
TMPK	Traditional Medicinal Plant Knowledge
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific, and Cultural Organization
WHO	World Health Organization
YZFEDD	Yem Zone Finance & Economic Development Department
YZNRAO	Yem Zone Natural Resources and Agriculture off

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Author Contributions

Addisu Shewaye Mengesha: Conceptualization, Data curation, Formal analysis, Methodology, Resources, Software, Visualization, Writing - original draft, Writing - review & editing

Kitessa Hundera: Conceptualization, Data curation, Formal analysis, Methodology, Software, Visualization, Writing - original draft, Writing - review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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