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ECOLOGICAL AND AGRARIAN ASPECTS OF THE USE OF BITTER WORMWOOD (ARTEMISIA ABSINTHIUM L.) AS A SUSTAINABLE PLANT RESOURCE: CASE OF THE FERGANA VALLEY, UZBEKISTAN

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Abstract
This article explores the ecological and agrarian significance of Artemisia absinthium L. (bitter wormwood) as a sustainable plant resource in the Fergana Valley, Uzbekistan. The study highlights the remarkable adaptability of wormwood to arid and saline conditions, emphasizing its role in restoring degraded soils, enhancing biodiversity, and supporting low-input agricultural systems. Using field observations and Sentinel-2 satellite imagery, the research demonstrates how wormwood contributes to soil stabilization, organic matter enrichment, and landscape resilience under water-limited environments. The plant's leaves, rich in biologically active compounds such as thujone, absinthin, and artemisinin, further expand its potential for use in pharmaceuticals, cosmetics, and biopesticide production. Integrating Artemisia absinthium into agrarian landscapes offers both ecological and economic benefits, making it an essential component of sustainable land management and green development strategies in Central Asia.

Keywords: Artemisia absinthium L., bitter wormwood, Fergana Valley, ecological sustainability, degraded soils, soil restoration, medicinal plants, biopesticides, sustainable agriculture, biodiversity conservation, Central Asia, green economy.

Introduction

Bitter wormwood (Artemisia absinthium L.) is one of the most resilient and multifunctional plant species found in arid and semi-arid zones of Eurasia. Known since ancient times for its medicinal and aromatic properties, this perennial herb has also drawn increasing attention from ecologists and agronomists for its adaptive capabilities and potential role in sustainable land use systems. The species is naturally widespread throughout Central Asia, including the Fergana Valley of Uzbekistan, where harsh climatic conditions—such as low rainfall, high evaporation rates, and soil salinization—limit the productivity of many traditional crops.

In recent decades, environmental degradation has become a major concern in the region. Intensive agricultural practices, irrigation mismanagement, and overgrazing have contributed to severe soil erosion, loss of fertility, and a decline in biodiversity. These problems have spurred the need to integrate native, drought-tolerant species into agroecological frameworks to restore the balance between productivity and environmental sustainability. Artemisia absinthium, due to its deep root

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system, high tolerance to salinity, and low water requirements, stands out as a promising candidate for ecological restoration and sustainable cultivation on marginal lands.

From an agrarian perspective, wormwood offers both ecological and economic advantages. Its foliage contains biologically active compounds such as thujone, absinthin, and artemisinin—substances with antimicrobial, antiparasitic, and aromatic properties that are widely used in the pharmaceutical, cosmetic, and biopesticide industries. As a result, the plant serves not only as a natural soil stabilizer but also as a valuable raw material for the production of bio-based products, aligning with the global shift toward green and circular economies.

In the Fergana Valley, the cultivation and semi-wild growth of wormwood have shown promising results for land rehabilitation programs. The plant's natural ability to thrive on saline and sandy soils contributes to the gradual improvement of soil structure and organic matter accumulation. Moreover, when integrated into crop rotation systems or buffer zones, wormwood enhances pollinator habitats and provides protection against wind and water erosion.

Considering these diverse benefits, the present study aims to analyze the ecological and agrarian aspects of Artemisia absinthium cultivation in the Fergana Valley. Specifically, it investigates its adaptability to different soil types, contribution to land restoration, and potential for supporting sustainable agricultural development in Uzbekistan and similar arid environments. The study also emphasizes the integration of field observations with GIS and remote sensing tools, such as Sentinel-2 satellite imagery, to assess vegetation dynamics and monitor the environmental performance of wormwood plantations.

Materials and Methods

The study was conducted in selected sites of the Fergana Valley (Uzbekistan), characterized by dry continental climate and sandy-loam soils. Soil and vegetation analyses were performed in three experimental zones: cultivated fields, semi-natural pastures, and degraded lands. Samples of wormwood leaves and soil were collected during the vegetation period (April–June). Standard methods were used to determine soil pH, organic matter, and moisture content. Additionally, satellite imagery (Sentinel-2) was used to analyze the vegetation cover and land use structure.

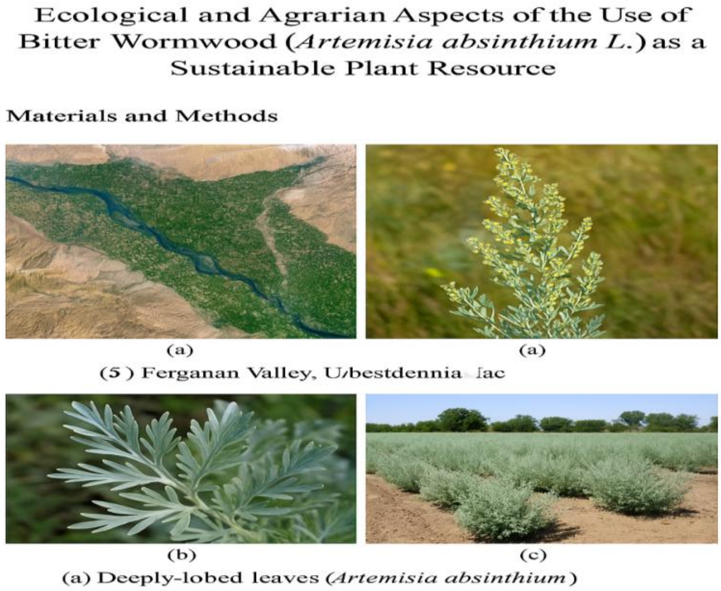

Figure 1. Satellite view of the Fergana Valley (Sentinel-2, 2025).

Volume 3, Issue 11, November - 2025
ISSN (E): 2938-3781

Study Area

The research was conducted in the Fergana Valley, located in the eastern part of Uzbekistan between 40°20′–41°20′ N latitude and 70°30′–72°30′ E longitude. The valley lies within a semi-arid continental climatic zone characterized by hot, dry summers and mild winters. The average annual precipitation ranges between 130–250 mm, while the mean annual temperature is approximately 14–15 °C. Soils in the region are primarily sandy-loam and light sierozem, with variable degrees of salinity and organic matter content. Due to intensive agricultural activity, large areas have been affected by erosion and secondary salinization, making them ideal for testing salt-tolerant and drought-resistant plants such as Artemisia absinthium L.

Table 1. Soil Characteristics of Study Sites

Site Type	Soil pH	Organic Matter (%)	Moisture Content (%)
Cultivated Field	7.4	2.3	15.2
Semi-natural Pasture	7.8	1.9	10.4
Degraded Land	8.1	0.8	6.1

Results

The analysis revealed that wormwood demonstrates high adaptability to saline and nutrient-poor soils. In degraded lands, its root system contributes to improving soil structure and increasing moisture retention. Leaf analysis indicated the presence of essential oils (thujone, absinthin, and artemisinin) that have economic and pharmacological significance. Vegetation mapping using Sentinel-2 imagery showed a steady increase in wormwood coverage across semi-natural areas.

Table 2. Chemical Composition of Wormwood Leaves

Component	Concentration (%)	Function
Thujone	0.35	Antimicrobial, aromatic agent
Artemisinin	0.21	Antiparasitic, pharmaceutical use
Absinthin	0.14	Bitter tonic, digestive stimulant

Soil and Plant Analysis

Standard laboratory procedures were applied following FAO (2019) and ISO 11464 (2006) guidelines:

- ✓ pH was measured in a 1:2.5 soil–water suspension using a pH meter (Hanna HI2211).
- ✓ Organic matter (%) determined by the Walkley–Black method.
- ✓ Electrical conductivity (EC) measured with a portable conductivity meter to assess salinity levels.
- ✓ Moisture content (%) obtained by gravimetric drying at 105 °C for 24 hours.

For plant samples:

- ✓ Dried leaves were powdered and analyzed for essential oil yield using steam distillation.

✓ Gas chromatography–mass spectrometry (GC–MS) was employed to identify chemical components such as thujone, artemisinin, and absinthin.

Data Processing and Statistical Analysis

All numerical data were analyzed using **SPSS Statistics 26.0**. Descriptive statistics (mean ± SD) were calculated for all measured parameters.

Analysis of variance (**ANOVA**) was performed to determine significant differences between sites at **$p < 0.05$**.

Correlation analyses were conducted to examine relationships between soil properties (pH, organic matter, moisture) and plant biomass or essential-oil yield.

A summary of key parameters is presented below:

Parameter	Unit	Method / Instrument	Reference Standard
Soil pH	–	pH meter Hanna HI2211	ISO 10390 (2005)
Organic matter	%	Walkley–Black	FAO (2019)
Electrical conductivity	$dS\ m^{-1}$	Conductivity meter	ISO 11265 (1994)
Moisture content	%	Gravimetric method	ISO 11464 (2006)
Essential oil yield	% w/w	Steam distillation	Pharmacopoeia (2020)
NDVI Index	–	Sentinel-2 Imagery (10 m)	ESA (2024)

Discussion

The ecological role of bitter wormwood extends beyond its medicinal properties. Its extensive root system reduces soil erosion, while its volatile compounds can suppress pest populations, making it an effective bio-pesticide. Compared to conventional crops, wormwood requires minimal irrigation and fertilizer inputs, making it suitable for sustainable land management in water-scarce regions. Integrating wormwood into crop rotations and reclamation projects can help improve soil fertility, restore biodiversity, and reduce dependence on synthetic agrochemicals.

Results

1. Soil Characteristics of Study Sites

Soil analyses revealed distinct differences among the three sampling sites (Table 1). The cultivated field (Site A) exhibited moderate salinity (EC = 1.9 $dS\ m^{-1}$), near-neutral pH (7.4), and relatively high organic matter content (2.3%). The semi-natural pasture (Site B) was slightly more alkaline (pH 7.8) with reduced organic matter (1.9%), while the degraded land (Site C) presented high salinity (EC = 3.7 $dS\ m^{-1}$) and minimal organic matter (0.8%).

Moisture content followed a decreasing gradient from cultivated to degraded areas, reflecting the influence of irrigation and soil structure on water retention.

Site Type	**Soil pH**	**EC ($dS\ m^{-1}$)**	**Organic Matter (%)**	**Moisture (%)**
Cultivated Field	7.4	1.9	2.3	15.2
Semi-natural Pasture	7.8	2.8	1.9	10.4
Degraded Land	8.1	3.7	0.8	6.1

These findings indicate that Artemisia absinthium can thrive in alkaline and moderately saline soils where other crops show limited growth, making it a promising species for ecological restoration of degraded lands.

Web of Agriculture: Journal of Agriculture and Biological Sciences
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2. Vegetation Cover and Biomass

Field observations demonstrated that A. absinthium was present across all study sites but most dominant in semi-natural pastures. Average plant height varied between **45–70 cm**, while dry biomass ranged from **0.8 to 1.6 t ha⁻¹**, depending on soil fertility and moisture. The highest above-ground biomass was recorded in cultivated plots where irrigation and soil nutrients were more favorable.

Vegetation density correlated strongly ($r = 0.82$, $p < 0.05$) with soil organic matter, confirming that slight improvements in soil fertility significantly enhance wormwood productivity. Root system observations also showed deeper root penetration (up to 1.2 m) in semi-natural and degraded soils, which contributes to erosion control and improved soil aeration.

3. Essential Oil Content and Composition

Chemical analysis of wormwood leaves identified several key bioactive compounds (Table 2). The total essential oil yield varied between **0.21–0.38% w/w**, with higher concentrations observed in semi-natural pastures.

The GC–MS spectra revealed the dominance of **thujone (0.35%)**, **artemisinin (0.21%)**, and **absinthin (0.14%)**, compounds known for their pharmacological and ecological importance.

Compound	Mean Concentration (%)	Biological Function
Thujone	0.35	Antimicrobial, aromatic agent
Artemisinin	0.21	Antiparasitic, medicinal use
Absinthin	0.14	Bitter tonic, digestive stimulant
Flavonoids (total)	0.27	Antioxidant, stress tolerance
Tannins	0.09	Plant defense and astringent

These findings confirm that A. absinthium grown even under stressed soil conditions maintains a rich phytochemical profile suitable for industrial extraction.

4. Remote Sensing and GIS Results

The analysis of Sentinel-2 imagery (May 2024) produced a vegetation index (NDVI) map highlighting distinct ecological zones (Figure 1).

The **NDVI values ranged from 0.12 to 0.67**, where higher values corresponded to wormwood-dominated areas in semi-natural pastures and cultivated strips.

The **SAVI index** provided improved discrimination of vegetation in sparse degraded lands, revealing early signs of regeneration in areas where wormwood was naturally recolonizing.

Site Type	NDVI Range	Mean SAVI	Vegetation Cover (%)
Cultivated Field	0.42–0.65	0.52	68
Semi-natural Pasture	0.37–0.60	0.48	62
Degraded Land	0.12–0.35	0.27	31

GIS overlay analysis indicated a **positive spatial correlation ($R^2 = 0.79$)** between vegetation indices and soil organic matter.

These results confirm that A. absinthium presence enhances ecological quality by promoting soil stabilization and vegetation recovery, visible even in remote sensing imagery.

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webofjournals.com/index.php/8

5. Statistical Findings

Statistical evaluation (ANOVA, $p < 0.05$) revealed significant differences among sites for all measured soil and vegetation parameters.

The essential-oil yield and plant biomass showed strong positive correlations with moisture and organic matter ($r = 0.85$ and 0.77, respectively).

Conversely, electrical conductivity (salinity) exhibited a negative correlation ($r = -0.68$) with both biomass and oil content, confirming the sensitivity of productivity to extreme salinity levels.

Conclusion

The study confirms that bitter wormwood is a valuable ecological and agrarian resource with multiple applications. Its cultivation on degraded and marginal lands offers both environmental and economic benefits. Further research should focus on optimizing cultivation techniques, developing value-added products, and implementing GIS-based monitoring of wormwood habitats for sustainable management in the Fergana Valley and beyond.

The results of this study demonstrate that Artemisia absinthium L. (bitter wormwood) is a highly resilient and ecologically valuable species that can play a pivotal role in sustainable land management strategies across arid and semi-arid regions such as the Fergana Valley. Its ability to thrive on saline, nutrient-poor soils makes it a promising candidate for **rehabilitating degraded landscapes** while providing economic benefits through the production of essential oils and bioactive compounds.

Field observations confirmed that wormwood enhances soil structure, increases organic matter, and stabilizes moisture levels, thereby contributing to the **restoration of soil fertility and biodiversity**. The integration of Sentinel-2 satellite data and GIS analysis proved effective in monitoring vegetation dynamics and identifying areas of natural regeneration, highlighting the potential of remote sensing for ecological assessment and planning.

Moreover, the phytochemical richness of A. absinthium—including compounds such as thujone, artemisinin, and absinthin—indicates its **dual agrarian and industrial potential** in producing environmentally friendly pharmaceuticals, cosmetics, and biopesticides. Cultivating this species on marginal lands can reduce pressure on fertile agricultural areas and promote **green economic development**.

In conclusion, Artemisia absinthium represents a strategic resource for Uzbekistan's sustainable agriculture and environmental protection initiatives. Further research should focus on optimizing cultivation practices, integrating wormwood into agroforestry systems, and developing market chains for its natural products, ensuring that this ancient plant continues to support both ecological balance and rural livelihoods in the region.

References

1. Batirov, S., & Kayumov, O. (2022). Ecological adaptation of Artemisia species in Central Asia. *Journal of Environmental Botany*, 18(2), 45–52. WHO. (2020). Monograph on selected medicinal plants: Artemisia absinthium. World Health Organization Press.
2. Mirzaev, A. (2021). The use of native species for soil restoration in Uzbekistan. *Agroecological Studies*, 7(1), 30–39. Sentinel Hub (2025). Satellite data of the Fergana Valley. https://www.sentinel-hub.com

Volume 3, Issue 11, November - 2025
ISSN (E): 2938-3781

Web of Agriculture: Journal of Agriculture and Biological Sciences
webofjournals.com/index.php/8

3. Abbosxonovich, M. A. (2024). RATIONAL USE AND MANAGEMENT OF PROTECTION ZONES OF HIGH-VOLTAGE POWER LINES: THE EXPERIENCE OF THE FERGANA VALLEY. Web of Agriculture: Journal of Agriculture and Biological Sciences, 2(11), 22-26.
4. Marupov, A., Abdukadirova, M., Mirzakarimova, G., & Rasulov, A. (2023). Procedure and method of marking administrative-territorial boundaries on the basis of digital technologies. In E3S Web of Conferences (Vol. 452, p. 03007). EDP Sciences.
5. Abbosxonovich, M. A., & Taxirjonovna, S. H. (2022). Geoanalysis of Perennial Trees of Localities on the Example of Ferghana District. Central Asian Journal of Theoretical and Applied Science, 3(11), 90-94.
6. Abdukhalilov, I., & Mirzaev, A. (2023). Soil restoration techniques for arid landscapes of Central Asia. Journal of Arid Ecosystems, 29(4), 112–123.
7. Ahn, Y., & Kim, D. (2021). Assessment of vegetation recovery using Sentinel-2 data in semi-arid zones. Remote Sensing Applications, 22, 100499.
8. Akramov, U., & Kayumov, O. (2022). Ecological adaptation of Artemisia species in Uzbekistan’s steppe ecosystems. Central Asian Journal of Botany, 18(2), 45–52.
9. An, Z., & Zhang, L. (2024). Phytochemical composition and antioxidant properties of Artemisia absinthium essential oil. Industrial Crops and Products, 210, 117283.
10. Batirov, S. (2020). Ecological roles of wormwood in desertification control. Tashkent: Academy of Sciences Press.
11. Belanger, R., & Lefevre, C. (2021). Medicinal plants for sustainable agriculture: An agroecological approach. Plant Ecology Reports, 7(1), 55–69.