



# Floristic diversity of ethnomedicinally important *Artemisia* species in Pakistan: An extensive overview of their distribution across regions, native status and global conservation concerns

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## Review

### Abstract

**Background:** Pakistan is recognized for its rich diversity of medicinal plants, with the genus *Artemisia* representing an ecologically and ethnobotanically important component of the flora. This review synthesizes information on distribution of reported *Artemisia* species across Pakistan with emphasis on their native status and conservation concerns.

**Methods:** The data for this review was systematically searched across various reputable scientific databases, including Web of Science, Scopus, MEDLINE and ScienceDirect using specific keywords.

**Results:** Earlier floristic treatments, including the Flora of Pakistan, documented 38 *Artemisia* species from various regions. The present compilation records a total of 66 species, reflecting a substantial increase in documented diversity from Pakistan. Growth-form analysis shows that herbaceous taxa dominate the genus in Pakistan (34 species), followed by shrubs (15 species). Most species are perennial (48 species), while annuals constitute a smaller fraction (6 species) with a few species exhibiting biennial or mixed life cycles. According to Plants of the World Online (POWO), *Artemisia* species in Pakistan occur primarily in temperate, subalpine, subtropical and desert habitats indicating broad ecological adaptability across altitudinal and climatic gradients. Of the 66 species recorded, 45 are mentioned as native to Pakistan, whereas the native status of 21 species remains unclear. The Flora of Pakistan and POWO revealed 38 species listed in both but only 31 species are consistently shared, highlighting taxonomic inconsistencies. Conservation assessments are notably limited, with only 13 species (20%) evaluated at the global level.

**Conclusion:** The increase in reported species from 38 to 66 in Pakistan may reflect improved taxonomic resolution, expand geographic surveys and increased ethnobotanical research and may or may not be an expansion of the genus in Pakistan. To

confirm this, future studies should prioritize underexplored regions resolve taxonomic ambiguities and integrate molecular and ecological approaches to better understand the diversity, conservation needs and expansion of the genus *Artemisia* in Pakistan.

**Keywords:** *Artemisia*, Ethnomedicinal significance, Distribution, Habitat, Native status, Global conservation status, Pakistan

## Background

*Artemisia* L. is one of the vital plant genera of the Asteraceae (formerly known as Compositae) family with ~500 accepted species mentioned in the Plants of the World Online (POWO 2025). The species are found mainly in the northern hemisphere of the world (Oberprieler *et al.* 2009; Bora & Sharma 2011). A number of secondary metabolites from *Artemisia* are used to cure various health problems including anxiety, stress, depression, irritability, epilepsy, psychoneurosis and insomnia (Walter *et al.* 2003). The *Artemisia* species are popular across the world due to their potential bioactivities such as antibacterial, antimalarial, antiseptic, antispasmodic, antirheumatic, antitumor, hepato-protective effects (Terra *et al.* 2007; Koul & Taak 2017; Hussain *et al.* 2017, 2019a, 2022; Pandey & Singh 2017; Mohammed *et al.* 2021), antiviral (Efferth *et al.* 2008; Kim *et al.* 2018; Nie *et al.* 2021; Hussain 2022), cytotoxic, antioxidant (Madhav *et al.* 2018; Cheraif *et al.* 2020; Jakovljevic *et al.* 2020) and antidiabetic activities (Dabe & Kefale 2017; Hussain 2024; Hussain & Bokhari 2025)

The classification of *Artemisia* specifically at the infrageneric level remained challenging and unresolved due to similarities or complexities in the morphological characters. For the genus *Artemisia*, various attempts have been made to address such issues in earlier studies (Torrell *et al.* 1999; Vallès & McArthur 2001). The current investigations based on molecular data divided *Artemisia* into six subgenera like Subg. *Artemisia*, Subg. *Absinthium*, Subg. *Tridantatae*, Subg. *Dracunculus*, Subg. *Seriphidium* and Subg. *Pacifica* (Hobbs & Baldwin 2013; Malik *et al.* 2017; Pellicer *et al.* 2018; Hussain 2022) as shown in Figure 1. It has been prophesized that the conservation of plants has been given less courtesy than animal's conservation (Goettsch *et al.* 2015). Due to this, plant conservation is prominently under resourced than the conservation of animals (Havens *et al.* 2013).

Plants provide food for both humans and animals and contribute to food security and nutrition with their uses as traditional medicine. Furthermore, plants provide a terrestrial ecosystem where animals live (Corlett 2016); hence, the conservation of plant species is very important. Habitat loss and degradation are the primary drivers of plant species decline, impacting approximately 91% of threatened plant species worldwide according to IUCN assessments (IUCN 2022). Decrease in plants population poses ecological impacts and affect ecosystem and biodiversity leading to nutrient cycle disruption, predator–prey dynamics difference, food webs interruption and pollination decrease (Rao & Larsen 2010).

The decline of native species affects the ecosystems due to their crucial roles in conserving habitat and ecosystem (Hobohm 2014); hence, native species are significant to clarify conservation primacies (Myers *et al.* 2000). Moreover, the reduction in genetic diversity inhibits the ability of species to acclimatize environmental fluctuations and increase their vulnerability to climate change and consequently decline more habitats (Frankham 2005). These may threaten the stability of ecosystem and destroy the environment to a greater extent (Chown & Gaston 2008). It has been validated that maximum number of medicinal plants of the world are found in the developing countries. For example, In Pakistan, there is diverse flora of almost 5600 to 700 species where nearly 2000 plant species have medicinal uses (Habibi 1997; Ullah 2017). The biodiversity of Pakistan is prominent in arid and semi-arid regions covering the total land area of almost 80%. Various plant and animal species are threatened or endangered due to the overuse and natural habitat loss. Some factors like overgrazing, deforestation, increase in population, soil erosion, pollution, spread of invasive alien species, higher habitat changes, waterlogging, climate fluctuations and salinity are key threats to the biodiversity in Pakistan (Baig & Al-Subaiee 2009; Khan & Hussain 2012). The forest habitat with a variety of plants and animals is descending continuously posing effects on natural and agricultural ecosystems of the country (Baig & Al-Subaiee 2009).

In Pakistan, no comprehensive compilation of recent data on the distribution status of ethnomedicinally significant *Artemisia* species exists. Although several individual research studies have been conducted, a unified contemporary overview addressing the distribution and conservation status of *Artemisia* plants is still lacking that is necessary to support ongoing research on their taxonomy and conservation. This review aims to address this gap by focusing on the most recent data regarding the distribution of *Artemisia* species in Pakistan, with a particular emphasis on their habitat, native status and global conservation status.

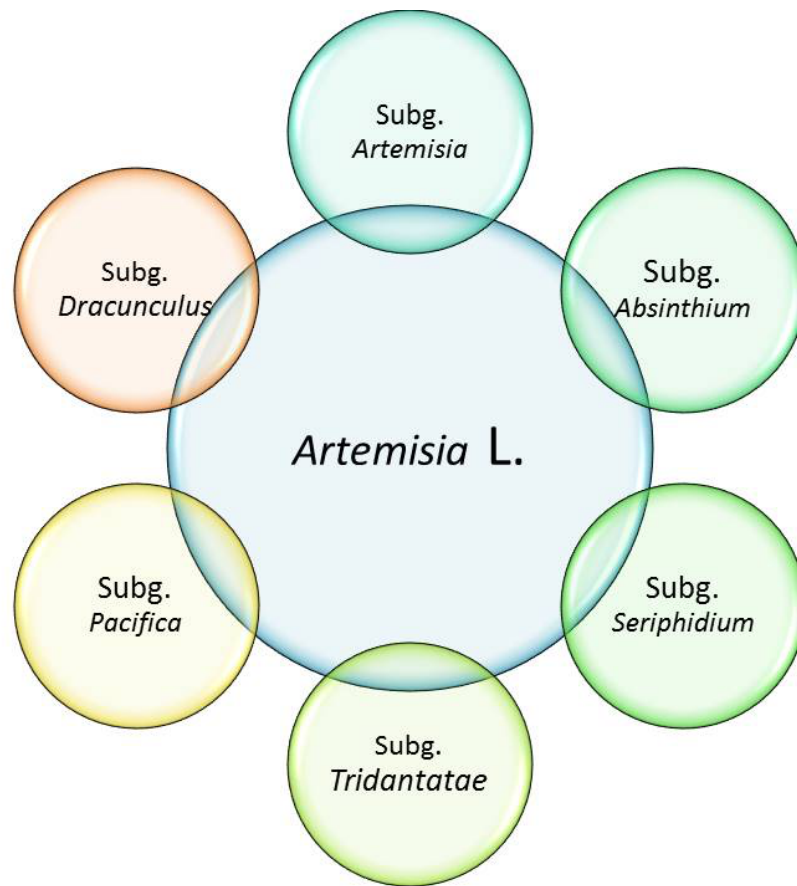


Figure 1. Classification of the genus *Artemisia* representing six major subgenera based on molecular data. Source: Hobbs & Baldwin (2013), Malik *et al.* (2017), Pellicer *et al.* (2018) & Hussain (2022).

## Materials and Methods

The data for this review was systematically searched across various reputable scientific databases, including Web of Science, Scopus, MEDLINE and ScienceDirect. A wide range of search terms was employed to ensure comprehensive coverage of the topic such as *Artemisia* genus, *Artemisia* in Pakistan, Distribution in Pakistan, Native status of *Artemisia*, Conservation of *Artemisia* in Pakistan, Rare *Artemisia* species in Pakistan, global conservation of *Artemisia*, *Artemisia* in Plants of the World Online database, *Artemisia* in the Flora of Pakistan, phytochemistry of *Artemisia* from Pakistan and Ethnobotany of *Artemisia* in Pakistan etc. To maintain the quality and reliability of the sources, only peer-reviewed research articles and review papers were considered with some regional reports. Additionally, papers published in English were selected, while those in other languages were excluded. The final dataset included a total of 270 papers on *Artemisia* from which data were meticulously extracted (Figure 2).

The review considered literature spanning from the earliest available records up to 2025, ensuring that both historical and recent data were accounted for. Duplicate records were identified and managed to maintain data integrity and in cases where species were listed under different names, the World Flora Online database was consulted to resolve discrepancies and ensure accurate identification. To address potential issues with synonyms and misidentifications, the review cross-referenced species names and their accepted classifications.

Finally, the list of *Artemisia* species was verified through comparison with authoritative databases, including Plants of the World Online (POWO), the Flora of Pakistan and World Flora Online to ensure the accuracy and completeness of the species recorded in this compilation. This thorough approach to data extraction and verification aimed to present a reliable overview of *Artemisia* species in Pakistan.

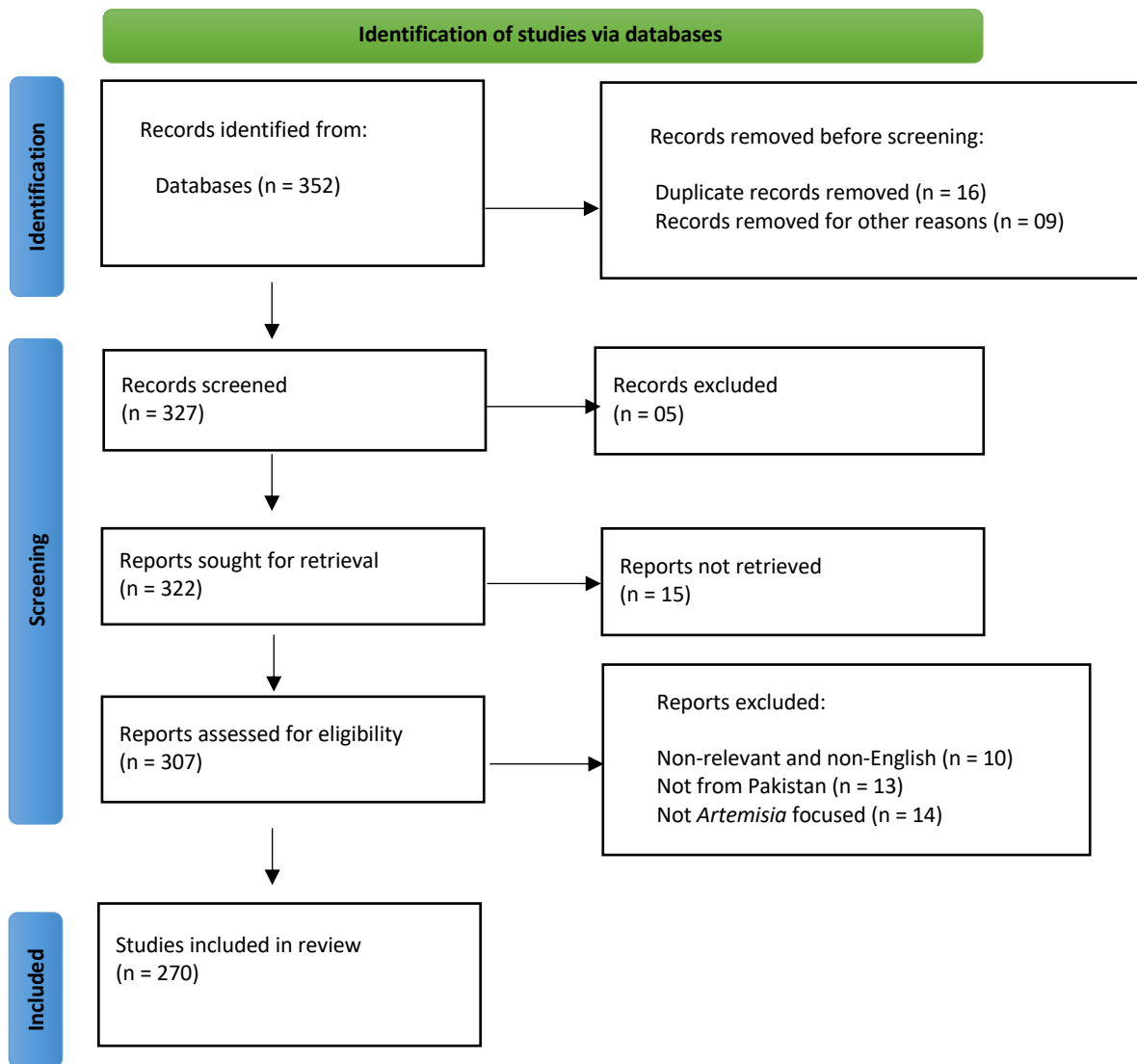


Figure 2. PRISMA flow diagram illustrating the systematic literature search and selection process for *Artemisia* species in Pakistan (Page et al. 2021)

### **Artemisia Diversity Patterns in Pakistan**

In the Flora of Pakistan, it has been reported that species number per genus is lower than the global average, presenting a higher diversity rate at genetic level. Among the endemic flowering plants of Pakistan, around 80% are present in the northern and western mountains (Ali & Qaiser 1986; Shinwari & Shinwari 2010). North Pakistan is prominently rich in species endemism and maximum endemic plant species are widespread in the mountains of Gilgit-Baltistan, Chitral and Kashmir above 1,000 m indicating altitude as one of the crucial indicators for species endemism (Qazi et al. 2023). In the Flora of Pakistan (Ghafoor 2002) and various other studies (Hayat et al. 2009a; Ashraf et al. 2010; Mannan et al. 2010; Nadeem et al. 2013), 38 *Artemisia* species (25 within *Artemisia* and 13 in *Seriphidium*) are mentioned in Pakistan mostly from the north frontier regions, Karakoram, Himalaya and Hindu Kush mountains, Gilgit, Chitral, Skardu, Swat, Rawalpindi, Abbottabad and Kashmir regions (Mannan et al. 2010); however, the native status of majority of the *Artemisia* species was not clearly reported. Based on the recently compiled data of this study, around 66 species of *Artemisia* have been reported from almost all regions of Pakistan including Punjab, Khyber Pakhtunkwa (KPK), Balochistan, Gilgit-Baltistan (GB), Islamabad Capital Territory (ICT), Federally Administered Tribal Areas (FATA) and Azad Jammu and Kashmir (AJK) (Table 1).

Table 1. Reported *Artemisia* species from different regions in Pakistan

<b>Artemisia spp.</b>	<b>Growth form</b>	<b>Life form</b>	<b>Locality</b>	<b>Reference</b>
<i>Artemisia absinthium</i> L.	Herb	Perennial	Peshawar, KPK	Khattak <i>et al.</i> (1985)
			Rawalpindi, Punjab	Qureshi <i>et al.</i> (2002)
			Deosai Astore, GB	Khan (2004)
			Siran Valley Mansehra, KPK	Shah and Khan (2006)
			Gilgit, GB	Qureshi <i>et al.</i> (2007)
			Gilgit, GB	Khan and Khatoon (2008)
			Gilgit, GB	Afzal <i>et al.</i> (2009)
			Naltar Gilgit, GB	Hayat <i>et al.</i> (2009a,b,c)
			Dir Kohistan, KPK	Jan <i>et al.</i> (2009)
			Lake Saf-ul-Malooq Kaghan, KPK	Ashraf <i>et al.</i> (2010)
			Naltar, Gilgit, GB	Hayat <i>et al.</i> (2010a,b)
			Astore, GB	Mannan <i>et al.</i> (2010)
			Kabal, Swat KPK	Ahmad <i>et al.</i> (2011)
			Kaghan, KPK	Awan <i>et al.</i> (2011)
			Kurram Agency KPK	Hussain <i>et al.</i> (2012)
			Gilgit, GB	Awan <i>et al.</i> (2013)
			Naran, KPK	Khan <i>et al.</i> (2013)
			ND	Nadeem <i>et al.</i> (2013)
			Haramosh, GB	Abbas <i>et al.</i> (2014)
			Agra Valley, Parachinar, Kurram Agency, KPK	Ajaib <i>et al.</i> (2014a)
			Deosai, GB	Bano <i>et al.</i> (2014a)
			Haripur, Abbottabad and Mansehra, KPK	Shah <i>et al.</i> (2014)
			KPK	Yaseen <i>et al.</i> (2015)
			Bajaur Agency, FATA	Aziz <i>et al.</i> (2017)
			South Waziristan and Bajaur Agency, FATA	Aziz <i>et al.</i> (2018a)
			Bajaur Agency, FATA	Aziz <i>et al.</i> (2018b)
			Koh-e-Safaid Range, Kurram Agency, KPK	Hussain <i>et al.</i> (2018)
			Kotli, AJK	Qaseem <i>et al.</i> (2018)
			Maruk Nallah, Haramosh, GB	Abbas <i>et al.</i> (2019)
			Kurran, KPK	Ali <i>et al.</i> (2019)
Naltar Gilgit, GB	Malik and Hayat (2019)			
Nagar, Kargah, GB	Salim <i>et al.</i> (2019)			

			Bannu, KPK	Ullah <i>et al.</i> (2019)
			Laspur Valley, Chitral, KPK	Wali S <i>et al.</i> (2019)
			Attabad Hunza- Nagar, GB	Hussain <i>et al.</i> (2020a)
			Peshawar, KPK	Shah <i>et al.</i> (2020)
			Swabi, KPK	Shahzadi <i>et al.</i> (2020)
			Sheen Ghar Valley, Dir Lower, KPK	Ullah <i>et al.</i> (2020)
			Palas Valley, Kohistan, KPK	Islam <i>et al.</i> (2021)
			Sudhnoti, AJK	Khan <i>et al.</i> (2021)
			Surghar range, KPK	Rahim <i>et al.</i> (2023)
			Shawal Valley, North Waziristan, KPK	Rehman <i>et al.</i> (2023a)
			Kohat, KPK	Shah <i>et al.</i> (2023)
			Punjab	Zareef <i>et al.</i> (2023)
			Sargodha, Punjab	Aziz <i>et al.</i> (2024)
			Upper Haramosh Valley, Gilgit, GB	<u>Din <i>et al.</i> (2024a)</u>
			Kharmang, GB	<u>Hussain B <i>et al.</i> (2024)</u>
			Palas Valley, Kohistan, KPK	Kayani <i>et al.</i> (2024)
<i>Artemisia amygdalina</i> Decne.	Herb	Perennial	Mansehra, KPK	Hayat <i>et al.</i> (2009b,c)
			Mansehra, KPK	Hayat <i>et al.</i> (2010a,b)
			Mansehra, KPK	Malik and Hayat (2019)
<i>Artemisia annua</i> L.	Herb	Annual	Shakargarh, Narowal, Punjab	Sardar and Khan (2009)
			Skardu, GB	Hayat <i>et al.</i> (2009a)
			Astore, GB	Mannan <i>et al.</i> (2010)
			Islamabad Capital Territory	Iqbal <i>et al.</i> (2012)
			Gahkuch, Ghizer, GB	Shedayi and Gulshan (2012)
			ND	Nadeem <i>et al.</i> (2013)
			Dir Lower, KPK	Ahmad <i>et al.</i> (2015)
			Khuiratta, AJK	Ajaib <i>et al.</i> (2015)
			Barmas paen Gilgit, GB	Hussain <i>et al.</i> (2019a,b,c)
			Skardu, GB	Malik and Hayat (2019)
			Ghizer, GB	Salim <i>et al.</i> (2019)
			Barmas Paen, Gilgit, GB	Hussain <i>et al.</i> (2020a)
			Diamir, GB	Wali <i>et al.</i> (2022)
<i>Artemisia arborescens</i> L.	Shrub	Perennial	Hacho paen Astore, GB	Hussain <i>et al.</i> (2019a)
<i>Artemisia argyi</i> H.Lév. & Vaniot	Herb	Perennial	Barmas Paen, Gilgit, GB	Hussain <i>et al.</i> (2019a,b)

<i>Artemisia austriaca</i> Jacq.	Herb or subshrub	Annual	Bagrote Valley, Gilgit, GB	Hussain <i>et al.</i> (2019a,b,c)
			Bagrote Valley Gilgit, GB	Hussain <i>et al.</i> (2020a)
<i>Artemisia biennis</i> Willd.	Herb	Annual or biennial	Murree Hills, Rawalpindi, Punjab	Hayat <i>et al.</i> (2009b,c)
			Murree Hills, Rawalpindi, Punjab	Hayat <i>et al.</i> (2010a,b)
			Chail Valley, Swat, KPK	Ahmad <i>et al.</i> (2014)
			Hazara, Bannu, Swat, Mansehra, KPK	Butt <i>et al.</i> (2015)
			Kurran, KPK	Ali <i>et al.</i> (2019)
			Naltar Valley, GB	Hussain <i>et al.</i> (2019a,b)
			Murree Hills, Rawalpindi, Punjab	Malik and Hayat (2019)
			Naltar Valley Gilgit, GB	Hussain <i>et al.</i> (2020a)
			Shigar Valley, Skardu, GB	Hussain <i>et al.</i> (2023)
			Jelar Valley, Dir Upper, KPK	Ullah S <i>et al.</i> , (2023)
<i>Artemisia bigelovii</i> A. Gray	Shrub	Annual	Laspur Valley, Chitral, KPK	Wali S <i>et al.</i> (2019)
<i>Artemisia brevifolia</i> Wall. ex DC.	Shrub	Perennial	Rawalpindi, Punjab	Qureshi <i>et al.</i> (2002)
			Kurram Agency, KPK	Gilani <i>et al.</i> (2003)
			Faisalabad, Punjab	Iqbal <i>et al.</i> (2004)
			Deosai Astore, GB	Khan (2004)
			Musakhel, Balochistan	Tareen <i>et al.</i> (2004)
			Swat, KPK	Hamayun <i>et al.</i> (2006a)
			Muzaffargarh, Punjab	Jabbar <i>et al.</i> (2006)
			Gilgit, GB	Khan and Khatoon (2008)
			Mansehra, Ujtar, KPK	Hayat <i>et al.</i> (2009a,c,d)
			Islamabad Capital Territory	Jabeen <i>et al.</i> (2009)
			Naran, KPK	Ashraf <i>et al.</i> (2010)
			Mansehra, Ujtar, KPK	Hayat <i>et al.</i> (2010a,b)
			Skardu, GB	Hussain <i>et al.</i> (2011)
			Khunjerab, GB	Khan B <i>et al.</i> (2011)
			Chitral, KPK	Khan N <i>et al.</i> (2011)
			Kaghan, KPK	Mahmood T <i>et al.</i> (2011)
			Miandam Valley, Swat KPK	Sher <i>et al.</i> (2011)
			Kohat, KPK	Shinwari <i>et al.</i> (2011)
Astore, GB	Noor <i>et al.</i> (2012)			
Gahkuch, Ghizer, GB	Shedayi and Gulshan (2012)			
Naltar, GB	Abbas <i>et al.</i> (2013)			

			ND	Nadeem <i>et al.</i> (2013)
			Skardu, GB	Bano <i>et al.</i> (2014b)
			Rech Valley, Chitral, KPK	Hadi <i>et al.</i> (2014)
			Hazara, Bannu, Swat, Mansehra, KPK	Butt <i>et al.</i> (2015)
			Turmic valley, Skardu GB	Khan SW <i>et al.</i> (2015)
			Tormik Valley, Skardu GB	Abbas <i>et al.</i> , (2016)
			Shigar, GB	Abbas <i>et al.</i> (2017)
			Mansehra, Ujtar, KPK	Malik and Hayat (2019)
			Astore, Ghizer, Gojal, Kargha, Nagar, Skardu, GB	Salim <i>et al.</i> (2019)
			Deosai Astore, GB	Abbas <i>et al.</i> (2021)
			Koh Valley, Chitral, KPK	Fazal and Badshsh (2024)
			Chitral, KPK	Ullah and Badshsh (2024)
<i>Artemisia bushiriensis</i>	Herb	Annual	Soost Gilgit, GB	Mannan <i>et al.</i> (2010)
<i>Artemisia campestris</i> L.	Shrub	Biennial or perennial	Naltar Valley, Gilgit, GB	Hussain <i>et al.</i> (2019a,c)
			Naltar Valley, Gilgit, GB	Hussain <i>et al.</i> (2020a)
<i>Artemisia capillaris</i> Thunb.	Herb	Biennial or perennial	Marghalla Hissla, Islamabad Capital Territory	Malik and Hayat (2019)
			Barmas, Gilgit, GB	Hussain <i>et al.</i> (2023)
<i>Artemisia chamaemelifolia</i> Vill.	Herb	Perennial	Naltar Valley, Gilgit, GB	Hussain <i>et al.</i> (2019a,b,c)
			Naltar Valley, Gilgit, GB	Hussain <i>et al.</i> (2020a)
			Ghizer, Gilgit, Hunza-Nagar and Skardu, GB	Hussain <i>et al.</i> (2020b)
			Manthoka, Skardu, GB	Hussain <i>et al.</i> (2023)
<i>Artemisia chitralensis</i> Podlech	Subshrub	Perennial	Utak, Chitral, KPK	Malik and Hayat (2019)
<i>Artemisia chinensis</i> L.	Herb	Perennial	Shangrilla, Sakrdu, GB	Hussain <i>et al.</i> (2019a,b,c)
			Shangrilla, Sakrdu, GB	Hussain (2022)
<i>Artemisia cina</i> Berg ex Poljakov	Herb	Perennial	<u>Dir Lower, KPK</u>	<u>Irfan <i>et al.</i>, (2023)</u>
<i>Artemisia desertorum</i> Spreng	Herb	Perennial	Mahthantir Gah, Gilgit, GB	Hayat <i>et al.</i> (2009c)
			Mahthantir Gah, Gilgit, GB	Hayat <i>et al.</i> (2010b)
			Shangla Swat, KPK	Mannan <i>et al.</i> (2010)
			Mahthantir Gah, Gilgit, GB	Malik and Hayat (2019)
<i>Artemisia dracunculus</i> L.	Herb	Perennial	Naltar Valley, Gilgit, GB	Hayat <i>et al.</i> (2009a)
			ND	Nadeem <i>et al.</i> (2013)
			Abbaspur, AJK	Mannan <i>et al.</i> (2010)
			Naltar Valley, Gilgit, GB	Malik and Hayat (2019)
<i>Artemisia dracunculus</i> Var.	Herb	Perennial	Rawalakot, AJK	Mannan <i>et al.</i> (2010)

<i>Artemisia dubia</i> Wall. ex Besser	Subshrub	Perennial	Shangla, KPK	Ibrar <i>et al.</i> (2007)
			Murree Hills, Rawalpindi, Punjab	Hayat <i>et al.</i> (2009a,b,c)
			Galyat, KPK	Ashraf <i>et al.</i> (2010)
			Murree Hills, Rawalpindi, Punjab	Hayat <i>et al.</i> (2010a,b)
			Galyat, KPK	Mannan <i>et al.</i> (2010)
			Ayubia, KPK	Mahmood T <i>et al.</i> (2011)
			Chakesar Valley, Shangla, KPK	Shah M and Hussain (2012)
			Gahkuch, Ghizer, GB	Shedayi and Gulshan (2012)
			ND	Nadeem <i>et al.</i> (2013)
			Kabal Swat, KPK	Khan SM <i>et al.</i> (2015)
			Danyore Oshkandas, Gilgit, GB	Hussain <i>et al.</i> (2019a,b)
			Murree Hills, Rawalpindi, Punjab	Malik and Hayat (2019)
			Lalku valley, Swat, KPK	Shah <i>et al.</i> (2020)
			Ghizer, GB	Salim <i>et al.</i> (2019)
Sakhra Valley, Swat, KPK	Shah <i>et al.</i> (2024)			
<i>Artemisia elegantissima</i> Pamp.	Herb	Perennial	Pirchanasi, Muzaffarabad, AJK	Rashid <i>et al.</i> (2014)
			Muzaffarabad, AJK	Malik and Hayat (2019)
			Musk Deer National Park, Neelum Valley, AJK	Hussain M <i>et al.</i> , (2024)
<i>Artemisia fragrans</i> Willd.	Herb	Perennial	Abbottabad, KPK	Sabeen <i>et al.</i> (2009)
			Central Karakoram National Park, Skardu, GB	Hussain <i>et al.</i> (2011)
			Ayubia National Park, KPK	Adnan <i>et al.</i> (2012)
			Nathiagali, Abbottabad, KPK	Begum <i>et al.</i> (2014)
			ND	Ahmad <i>et al.</i> (2016)
			Skardu, GB	Salim <i>et al.</i> (2019)
<i>Artemisia freitagii</i> Podlech	Subshrub	Unknown	Hanna Lake, Quetta Balochistan	Malik and Hayat (2019)
<i>Artemisia glacialis</i> L.	Herb	Perennial	Diamir, GB	Wali R <i>et al.</i> (2019)
<i>Artemisia glanduligera</i> Krasch. ex Poljakov.	Subshrub	Unknown	Parachinar, Kurram Agency, KPK	Malik and Hayat (2019)
<i>Artemisia gmelinii</i> Weber ex Stechm.	Shrub	Perennial	Deosai Astore, GB	Khan (2004)
			Hispar, GB	Hayat <i>et al.</i> (2009c)
			Hispar, GB	Hayat <i>et al.</i> (2010b)
			Naltar, GB	Abbas <i>et al.</i> (2013)
			Haramosh, GB	Abbas <i>et al.</i> (2014)
			Turmuc Valley, Skardu GB	Khan SW <i>et al.</i> (2015)

			Naltar Valley, Gilgit, GB	Hussain <i>et al.</i> (2019a,b,c)
			Hispar, GB	Malik and Hayat (2019)
			Ata abad Hunza Nagar, GB	Hussain <i>et al.</i> (2023)
			Kohistan, KPK	Amin <i>et al.</i> (2024)
<i>Artemisia herba-alba</i> Asso.	Shrub	Perennial	Hanna lake, Quetta, Balochistan	Hayat <i>et al.</i> (2009a,c)
			Hanna lake, Quetta, Balochistan	Hayat <i>et al.</i> (2010b)
			Gahkuch, Ghizer, GB	Shedayi and Gulshan (2012)
			Kargah Nala, Gilgit, GB	Hussain <i>et al.</i> (2019a,b,c)
			Hanna lake, Quetta, Balochistan	Malik and Hayat (2019)
			Ghizer, GB	Salim <i>et al.</i> (2019)
			Kargah Nala, Gilgit, GB	Hussain <i>et al.</i> (2020a)
			Kargah Nala, Gilgit, GB	Hussain <i>et al.</i> (2023)
			Koh Valley, Chitral, KPK	Fazal and Badshsh (2024)
<i>Artemisia incisa</i> Pamp.	Herb	Perennial	Lower Dir, KPK	Rashid <i>et al.</i> (2016)
			Abbottabad, KPK	Malik and Hayat (2019)
			Musk Deer National Park, Neelum Valley, AJK	Hussain M <i>et al.</i> , (2024)
<i>Artemisia indica</i> Willd.	Herb or subshrub	Perennial	Buner, Swat, Chitral KPK	Khan <i>et al.</i> (2007)
			Hazara, KPK	Rauf <i>et al.</i> (2007)
			Gilgit, GB	Afzal <i>et al.</i> (2009)
			Shangla Swat, KPK	Mannan <i>et al.</i> (2010)
			Ayubia National Park, KPK	Adnan <i>et al.</i> (2012)
			Gilgit, GB	Awan <i>et al.</i> (2013)
			Yasin, Ghizer, GB	Hussain <i>et al.</i> (2019a,b,c)
			Yasin, Ghizer, GB	Hussain <i>et al.</i> (2020a)
			Shishi Koh Valley, Chitral, KPK	Wali <i>et al.</i> (2022)
			Barmas Gilgit, GB	Hussain <i>et al.</i> (2023)
			Koh Valley, Chitral, KPK	Fazal and Badshsh (2024)
			Gilgit, GB	Rasheed <i>et al.</i> (2025)
			Kohat, KPK	Zamin <i>et al.</i> (2024)
<i>Artemisia japonica</i> Thunb.	Herb	Perennial	Murree Hills, Rawalpindi, Punjab	Hayat <i>et al.</i> (2009a,b,c)
			Shugran, KPK	Ashraf <i>et al.</i> (2010)
			Murree Hills, Rawalpindi, Punjab	Hayat <i>et al.</i> (2010a,b)
			Galyat, KPK	Mannan <i>et al.</i> (2010)
			Rawalakot, AJK	Mahmood T <i>et al.</i> (2011)

			Astore, GB	Noor <i>et al.</i> (2012)
			Chakesar Valley, Shangla, KPK	Shah M and Hussain (2012)
			ND	Nadeem <i>et al.</i> (2013)
			Murree Hills, Rawalpindi, Punjab	Malik and Hayat (2019)
			Bagh, AJK	Arif <i>et al.</i> (2021)
			Koh Valley, Chitral, KPK	Fazal and Badshsh (2024)
<i>Artemisia kurramensis</i> Qazilb.	Shrub	Perennial	Kurram Agency, KPK	Qazilbash (1950)
			Kurram Agency, KPK	Hayat <i>et al.</i> (2009b,c)
			Kurram Agency, KPK	Hayat <i>et al.</i> (2010a,b)
			ND	Nadeem <i>et al.</i> (2013)
			Kurram Agency, KPK	Malik and Hayat (2019)
			Dir Lower, KPK	Irfan <i>et al.</i> , (2023)
<i>Artemisia laciniata</i> Willd.	Shrub	Perennial	Gilgit, GB	Fahad and Bano (2012)
			Naltar, Gilgit, GB	Malik and Hayat (2019)
			Kargah Gilgit, GB	Salim <i>et al.</i> (2019)
<i>Artemisia leucotricha</i> Krasch. ex Ladygina	Herb	Perennial	Naltar, Gilgit, GB	Hayat <i>et al.</i> (2009b)
			Naltar, Gilgit, GB	Hayat <i>et al.</i> (2010a)
			Naltar, Gilgit, GB	Malik and Hayat (2019)
<i>Artemisia macrocephala</i> Jacquem. ex Besser	Herb	Annual	Naltar, Gilgit, GB	Hayat <i>et al.</i> (2009b)
			Naltar, Gilgit, GB	Hayat <i>et al.</i> (2010a)
			Neelum Valley, AJK	Mahmood <i>et al.</i> (2011a)
			Leepa Valley, AJK	Mahmood <i>et al.</i> (2012a)
			Dir Lower, KPK	Ali <i>et al.</i> (2013)
			ND	Nadeem <i>et al.</i> (2013)
			Dir Lower, KPK	Shoaib <i>et al.</i> (2017)
			Naltar, Gilgit, GB	Malik and Hayat (2019)
<i>Artemisia maritima</i> L.	Shrub	Perennial	Gilgit, GB	Chaudhri (1962)
			Khanabad, Gilgit, GB	Gorsi and Miraj (2002)
			Kurram Agency, KPK	Gilani <i>et al.</i> (2003)
			Deosai Astore, GB	Khan (2004)
			Musakhel, Balochistan	Tareen <i>et al.</i> (2004)
			Shangla, KPK	Ibrar <i>et al.</i> (2007)
			Gilgit, GB	Qureshi <i>et al.</i> (2007)
			Mardan, KPK	Akhtar and Begum (2009)

			Kurran Agency, KPK	Hayat <i>et al.</i> (2009a)
			Skardu, GB	Hayat <i>et al.</i> (2009d)
			Samahni, AJK	Hussain and Chaudhary (2009)
			Dir Kohistan, KPK	Jan <i>et al.</i> (2009)
			Gilgit, GB	Khan <i>et al.</i> , (2009)
			Malam Jabba, Swat KPK	Sher and Hussain (2009)
			Skardu, GB	Ashraf <i>et al.</i> (2010)
			Skardu, GB	Hayat <i>et al.</i> (2010a)
			Suleiman mountain, Balochistan	Raziq <i>et al.</i> (2010)
			Chagharzai, Buner, KPK	Alam <i>et al.</i> (2011)
			Chitral, KPK	Khan N <i>et al.</i> (2011)
			Quetta, Balochistan	Shah <i>et al.</i> (2011)
			Gilgit-Baltistan	Fahad and Bano (2012)
			Gahkuch, Ghizer, GB	Shedayi and Gulshan (2012)
			Naltar, GB	Abbas <i>et al.</i> (2013)
			Haramosh, GB	Abbas <i>et al.</i> (2014)
			Bannu, KPK	Adnan <i>et al.</i> (2014)
			Deosai, Astore, GB	Bano <i>et al.</i> (2014a)
			Barawal Bandi Dir, KPK	Hussain <i>et al.</i> (2014)
			Haripur, Abbottabad and Mansehra, KPK	Shah <i>et al.</i> (2014)
			Ghizer, GB	Shedayi <i>et al.</i> (2014)
			Hazara, Bannu, Swat, Mansehra, KPK	Butt <i>et al.</i> (2015)
			ND	Ahmad <i>et al.</i> (2016)
			Swat, KPK	Ali K <i>et al.</i> (2018)
			Haramosh, Gilgit-Baltistan	Abbas <i>et al.</i> (2019)
			Bagrote Valley, Gilgit, GB	Hussain <i>et al.</i> (2019a)
			Minawar, Gilgit, GB	Hussain <i>et al.</i> (2019c)
			Kurran Agency, KPK	Malik and Hayat (2019)
			Astore, Ghizer, Gojal, Kargha, Nagar, Skardu, GB	Salim <i>et al.</i> (2019)
			Diamir, GB	Wali R <i>et al.</i> (2019)
			Minawar, Gilgit, GB	Hussain <i>et al.</i> (2020a)
			Muzaffarabad, AJK	Raja <i>et al.</i> (2020)
			Swabi, KPK	Shahzadi <i>et al.</i> (2020)
			Deosai Astore, Gilgit-Baltistan	Abbas <i>et al.</i> (2021)

			Hazarganji, Balochistan	Rehman <i>et al.</i> (2021)
			Diamir, Gilgit-Baltistan	Wali <i>et al.</i> (2022)
			Peshawar, KPK	Zaman <i>et al.</i> , (2022)
			Barmas Gilgit, GB	Hussain <i>et al.</i> (2023)
			<u>Dir Lower, KPK</u>	<u>Irfan <i>et al.</i>, (2023)</u>
			Shawal Valley, North Waziristan, KPK	Rehman <i>et al.</i> (2023a)
			North Waziristan, KPK	Rehman <i>et al.</i> (2023b)
			Swabi, KPK	Ullah F <i>et al.</i> (2023)
			Kutwal Haramosh Valley, Gilgit, GB	Din <i>et al.</i> (2024b)
			Koh Valley, Chitral, KPK	Fazal and Badshsh (2024)
			Koh Valley, Chitral, KPK	Fazal <i>et al.</i> , (2024)
			Sudhnoti, AJK	Ishtiaq <i>et al.</i> (2024)
			Gilgit, GB	Rasheed <i>et al.</i> (2025)
<i>Artemisia minor</i> Jacquem. ex Besser	Herb	Perennial	Neelum Valley, AJK	Malik and Hayat (2019)
<i>Artemisia montana</i> Pamp.	Herb	Perennial	Hashupi Shigar, Skardu, GB	Hussain <i>et al.</i> (2019b,c)
<i>Artemisia moorcroftiana</i> Wall. ex DC.	Herb	Perennial	Muzaffarabad, AJK	Hayat <i>et al.</i> (2009b,c)
			Galyat, KPK	Ashraf <i>et al.</i> (2010)
			Muzaffarabad, AJK	Hayat <i>et al.</i> (2010a,b)
			Kalam Swat, KPK	Mannan <i>et al.</i> (2010)
			ND	Nadeem <i>et al.</i> (2013)
			Murree Hills, Rawalpindi, Punjab	Malik and Hayat (2019)
<i>Artemisia oliveriana</i> J.Gay ex Besser	Subshrub	Perennial	ND	Nadeem <i>et al.</i> (2013)
			Khuzdar, Balochistan	Malik and Hayat (2019)
			Ziarat, Balochistan	Rehman <i>et al.</i> (2021)
<i>Artemisia parviflora</i> Roxb. ex D.Don	Herb or subshrub	Perennial	Booni Chitral, KPK	Ahmad S <i>et al.</i> , (2006)
			Chitral, KPK	Khan N <i>et al.</i> (2011)
			Chitral, KPK	Shah SM and Hussain (2012)
			Rech Valley, Chitral, KPK	Hadi <i>et al.</i> (2014)
			Shishi Koh Valley, Chitral, KPK	Wali <i>et al.</i> (2021)
			Koh Valley, Chitral, KPK	Fazal and Badshsh (2024)
			Koh Valley, Chitral, KPK	Fazal <i>et al.</i> , (2024)
			Chitral, KPK	Ullah and Badshsh (2024)
<i>Artemisia persica</i> Boiss.	Shrub	Perennial	Rawalakot, AJK	Mannan <i>et al.</i> (2010)
			Swat, KPK	Hayat <i>et al.</i> (2009b)

			Swat, KPK	Hayat <i>et al.</i> (2010a)
			Kaghan, KPK	Mahmood T <i>et al.</i> (2011)
			Quetta, Balochistan	Baloch <i>et al.</i> (2013)
			Northern area, KPK	Raza <i>et al.</i> (2013)
			Kalash Valley, Chitral, KPK	Ullah <i>et al.</i> (2014)
			Deosai Astore, GB	Bano <i>et al.</i> (2015)
			Swat, KPK	Malik and Hayat (2019)
			Koh Valley, Chitral, KPK	Fazal and Badshsh (2024)
<i>Artemisia pontica</i> L.	Herb or subshrub	Perennial	Bagrote Valley, Gilgit, GB	Hussain <i>et al.</i> (2019c)
<i>Artemisia quettensis</i> (Podlech.) Ling.	Shrub	Perennial	Mastung, Balochistan	Bibi <i>et al.</i> (2014)
			Koh Marat, Kalat, Balochistan	Malik and Hayat (2019)
			Hazarganji, Balochistan	Rehman <i>et al.</i> (2021)
<i>Artemisia roxburghiana</i> Wall. ex Besser	Herb	Perennial	Islamabad Capital territory	Hussain <i>et al.</i> (2004)
			Hazara, KPK	Rauf <i>et al.</i> (2007)
			Murree Hills, Rawalpindi, Punjab	Hayat <i>et al.</i> (2009a,b,c)
			Galyat, KPK	Ashraf <i>et al.</i> (2010)
			Murree Hills, Rawalpindi, Punjab	Hayat <i>et al.</i> (2010a,b)
			Rawalakot, AJK	Mannan <i>et al.</i> (2010)
			Rawalakot, AJK	Mahmood T <i>et al.</i> (2011)
			Ayubia National Park, KPK	Adnan <i>et al.</i> (2012)
			ND	Nadeem <i>et al.</i> (2013)
			Mansehra, KPK	Shah MR <i>et al.</i> (2016)
			Murree Hills, Rawalpindi, Punjab	Malik and Hayat (2019)
<i>Artemisia roxburghiana</i> var <i>grata</i>	Herb	Perennial	Murree, Rawalpindi Punjab	Mannan <i>et al.</i> (2010)
<i>Artemisia rutifolia</i> Steph. ex Spreng.	Subshrub or shrub	Perennial	Chitral, KPK	Ali and Qaiser (2009)
			Naltar, Gilgit, GB	Hayat <i>et al.</i> (2009c,d)
			Naltar, Gilgit, GB	Hayat <i>et al.</i> (2010a,b)
			Skardu, GB	Hussain <i>et al.</i> (2011)
			Hunza-Nagar, GB	Hyder <i>et al.</i> (2013)
			Kalash Valley, Chitral, KPK	Ullah <i>et al.</i> (2014)
			Chitral, KPK	Ashraf <i>et al.</i> (2017)
			Naltar Valley, Gilgit, GB	Hussain <i>et al.</i> (2019a)
			Naltar, Gilgit, GB	Malik and Hayat (2019)

			Kargah Gilgit, GB	Salim <i>et al.</i> (2019)
			Ata abad Hunza-Nagar, GB	Hussain <i>et al.</i> (2022)
			Dir Lower, KPK	Irfan <i>et al.</i> , (2023)
			Koh Valley, Chitral, KPK	Fazal and Badshsh (2024)
			Kharmang, GB	Hussain B <i>et al.</i> (2024)
			Allah Wali Lake Gutumsar, Astore, GB	Khadim <i>et al.</i> (2024a)
			Theeing Valley, Astore, GB	Khadim <i>et al.</i> (2024b)
<i>Artemisia rutifolia</i> var. <i>altaica</i> (Krylov) Krasch	Subshrub or shrub	Perennial	Naltar Valley, Gilgit, GB	Hussain <i>et al.</i> (2019c)
			Sadpara Lake Skardu, GB	Hussain <i>et al.</i> (2020a)
			Ata Abad, Hunza-Nagar, GB	Hussain <i>et al.</i> (2023)
<i>Artemisia rutifolia</i> var. <i>ruoqiangensis</i> Y.R.Ling	Subshrub or shrub	Perennial	Naltar Valley, Gilgit, GB	Hussain <i>et al.</i> (2020a)
<i>Artemisia salsoloides</i> Willd.	Shrub	Perennial	Murree Hills, Rawalpindi, Punjab	Malik and Hayat (2019)
<i>Artemisia santolinifolia</i> Turcz. ex Krasch.	Herb	Perennial	Booni Chitral, KPK	Ahmad S <i>et al.</i> (2006)
			Naltar Gilgit, GB	Hayat <i>et al.</i> (2009a,c,d)
			Naltar Gilgit, GB	Hayat <i>et al.</i> (2010a,b)
			Chakesar Valley, Shangla, KPK	Shah M and Hussain (2012)
			ND	Nadeem <i>et al.</i> (2013)
			Dir, KPK	Hazrat <i>et al.</i> (2015)
			Turmic valley, Skardu GB	Khan SW <i>et al.</i> (2015)
			Shigar, Skardu GB	Abbas <i>et al.</i> (2017)
			Naltar, Gilgit, GB	Malik and Hayat (2019)
			Skardu, GB	Salim <i>et al.</i> (2019)
			Kutwal Haramosh Valley, Gilgit, GB	Din <i>et al.</i> (2024b)
			Koh Valley, Chitral, KPK	Fazal and Badshsh (2024)
			Allah Wali Lake Gutumsar, Astore, GB	Khadim <i>et al.</i> (2024a)
			Theeing Valley, Astore, GB	Khadim <i>et al.</i> (2024b)
<i>Artemisia scentonema</i>	Unknown	Unknown	Chakesar Valley, Shangla, KPK	Shah M and Hussain (2012)
<i>Artemisia scoparia</i> Waldst. & Kit.	Herb	Biennial or perennial	Thatta, Sindh	Gilani <i>et al.</i> (1994)
			Islamabad, Islamabad Capital Territory	Shinwari and Khan (2000)
			Kahuta Rawalpindi, Punjab	Qureshi and Khan (2001)
			Rawalpindi, Punjab	Qureshi <i>et al.</i> (2002)
			Lawat, Muzaffarabad, AJK	Dar (2003)
			Gokand, Buner KPK	Khan <i>et al.</i> (2003)

			Attock, Punjab	Ahmad M <i>et al.</i> (2006)
			Swat, KPK	Hamayun <i>et al.</i> (2006b)
			Ghalegay, Swat, KPK	Hussain <i>et al.</i> (2006)
			Lahore-Islamabad Motorway, Punjab	Ahmad (2007)
			Ayubia, KPK	Ahmad and Javed (2007)
			Hazara, KPK	Rauf <i>et al.</i> (2007)
			Kallar Kahar, Punjab	Ahmad and Husain (2008)
			Pindigheb, Punjab	Hayat <i>et al.</i> (2008)
			Gilgit, GB	Khan and Khatoon (2008)
			Mardan, KPK	Akhtar and Begum (2009)
			Quaid I Azam University, Islamabad Capital Territory	Hayat <i>et al.</i> (2009a,c,d)
			Dir Kohistan, KPK	Jan <i>et al.</i> (2009)
			Chagharzai, Buner, KPK	Alam <i>et al.</i> (2011)
			Quaid I Azam University, Islamabad Capital Territory	Hayat <i>et al.</i> (2010a,b)
			Jalalpur Jattan Gujrat, Punjab	Hussain <i>et al.</i> (2010)
			Kalat and Khuzdar, Balochistan	Tareen <i>et al.</i> (2010)
			Kabal, Swat KPK	Ahmad <i>et al.</i> (2011)
			Dir Kohistan, KPK	Hazrat <i>et al.</i> (2011)
			Bhimber, AJK	Mahmood <i>et al.</i> (2011b)
			Miandam Valley, Swat KPK	Sher <i>et al.</i> (2011)
			Ayubia National Park, KPK	Adnan <i>et al.</i> (2012)
			Leepa valley, Muzaffarabad, AJK	Ishtiaq <i>et al.</i> (2012)
			Kotli, AJK	Mahmood <i>et al.</i> , (2012b)
			Astore, GB	Noor <i>et al.</i> (2012)
			Chakesar Valley, Shangla, KPK	Shah M and Hussain (2012)
			Gahkuch, Ghizer, GB	Shedayi and Gulshan (2012)
			Patriata, New Murree Punjab	Ahmed <i>et al.</i> (2013)
			Swat, KPK	Akhtar <i>et al.</i> (2013)
			Quetta, Balochistan	Baloch <i>et al.</i> (2013)
			Bhimber, AJK	Hussain <i>et al.</i> (2013)
			Gujranwala, Punjab	Mahmood <i>et al.</i> (2013)
			ND	Nadeem <i>et al.</i> (2013)
			Neelum valley, AJK	Ahmad and Habib (2014)
			Agra Valley, Parachinar, Kurram Agency, KPK	Ajaib <i>et al.</i> (2014a)

			Gujrat, Punjab	Ajaib <i>et al.</i> (2014b)
			Parachinar, KPK	Khan <i>et al.</i> (2014)
			Malakand, KPK	Barkatullah <i>et al.</i> (2015)
			Hazara, Bannu, Swat, Mansehra, KPK	Butt <i>et al.</i> (2015)
			Dir, KPK	Hazrat <i>et al.</i> (2015)
			Quaid I Azam University, Islamabad Capital Territory	Khan K <i>et al.</i> (2015)
			Kabal Swat, KPK	Khan SM <i>et al.</i> (2015)
			Tormik Valley, GB	Abbas <i>et al.</i> , (2016)
			ND	Ahmad <i>et al.</i> (2016)
			Swat, KPK	Shah SA <i>et al.</i> (2016)
			Chitral, KPK	Sher <i>et al.</i> (2016)
			Ladha South Waziristan, FATA	Aziz <i>et al.</i> (2016)
			Shigar, Skardu GB	Abbas <i>et al.</i> (2017)
			Kel Village Neelum Valley, AJK	Ahmad <i>et al.</i> (2017)
			Sheikupura, Punjab	Zahoor <i>et al.</i> (2017)
			Swat, KPK	Ali A <i>et al.</i> (2018)
			South Waziristan and Bajaur Agency, FATA	Aziz <i>et al.</i> (2018a)
			Bajaur Agency , FATA	Aziz <i>et al.</i> (2018b)
			Mohmand Agency, FATA	Aziz <i>et al.</i> (2018c)
			Koh-e-Safaid Range, Kurram Agency, KPK	Hussain <i>et al.</i> (2018)
			Rawalpindi, Punjab	Ashfaq <i>et al.</i> (2019)
			Kachura Lake, Skardu, GB	Hussain <i>et al.</i> (2019a,c)
			Quaid I Azam University, Islamabad Capital Territory	Malik and Hayat (2019)
			Bhimber, AJK	Maqbool <i>et al.</i> (2019)
			Ghizer, Kargha, Skardu, GB	Salim <i>et al.</i> (2019)
			Bannu, KPK	Ullah <i>et al.</i> (2019)
			Chenab River, Punjab	Umair <i>et al.</i> (2019)
			Kachura Lake, Skardu, GB	Hussain <i>et al.</i> (2020a)
			Deosai Skardu, GB	Abbas <i>et al.</i> (2021)
			Jhelum valley, AJK	Awan <i>et al.</i> (2021)
			Palas Valley, Kohistan, KPK	Islam <i>et al.</i> (2021)
			Upper Dir, KPK	Shuaib <i>et al.</i> (2021)
			Swat, KPK	Ali <i>et al.</i> (2023)
			Madyan Swat, KPK	Dilbar <i>et al.</i> (2023)

			Dir Lower, KPK	<a href="#">Irfan et al., (2023)</a>
			Muzaffarabad, AJK	<a href="#">Mirzaman et al. (2023)</a>
			Surghar range, KPK	<a href="#">Rahim et al. (2023)</a>
			Swabi, KPK	<a href="#">Ullah F et al. (2023)</a>
			Kallar Syedan, Rawalpindi Punjab	<a href="#">Zareef et al. (2023)</a>
			Kutwal Haramosh Valley, Gilgit, GB	<a href="#">Din et al. (2024b)</a>
			Koh Valley, Chitral, KPK	<a href="#">Fazal and Badshsh (2024)</a>
			Koh Valley, Chitral, KPK	<a href="#">Fazal et al., (2024)</a>
			Allah Wali Lake Gutumsar, Astore, GB	<a href="#">Khadim et al. (2024a)</a>
			Theeing Valley, Astore, GB	<a href="#">Khadim et al. (2024b)</a>
			Bhimber, AJK	<a href="#">Khanum et al. (2024)</a>
			Sakhra Valley, Swat, KPK	<a href="#">Shah et al. (2024)</a>
			Riverine areas, Punjab	<a href="#">Umair et al. (2024)</a>
<i>Artemisia sieberi</i> Besser	Shrub	Perennial	Barmas Bala, Gilgit, GB	<a href="#">Hussain et al. (2019a)</a>
			Hanna Lake, Quetta, Balochistan	<a href="#">Malik and Hayat (2019)</a>
			Punjab	<a href="#">Zareef et al. (2023)</a>
<i>Artemisia sieversiana</i> Ehrh. ex Willd.	Herb	Annual or biennial	Gilgit, GB	<a href="#">Khan and Khatoon (2008)</a>
			Naltar, Gilgit, GB	<a href="#">Hayat et al. (2009b,c)</a>
			Naltar, Gilgit, GB	<a href="#">Hayat et al. (2010a,b)</a>
			Soost Gilgit, GB	<a href="#">Mannan et al. (2010)</a>
			Astore, GB	<a href="#">Noor et al. (2012)</a>
			Hunza-Nagar, GB	<a href="#">Hyder et al. (2013)</a>
			Skardu, GB	<a href="#">Bano et al. (2014b)</a>
			Naltar, Gilgit, GB	<a href="#">Malik and Hayat (2019)</a>
			Astore, Kargha, Nagar, Skardu, GB	<a href="#">Salim et al. (2019)</a>
			Khalti Lake, Ghizer, GB	<a href="#">Hussain et al. (2020a)</a>
			Kutwal Haramosh Valley, Gilgit, GB	<a href="#">Din et al. (2024b)</a>
			Gilgit, GB	<a href="#">Hussain A et al. (2024)</a>
<i>Artemisia stenocephala</i> Krasch. ex Poljakov	Subshrub	Unknown	Chalas, GB	<a href="#">Hayat et al. (2009d)</a>
			Chalas, GB	<a href="#">Hayat et al. (2010a)</a>
			Chalas, GB	<a href="#">Malik and Hayat (2019)</a>
			Shinghar, Balochistan	<a href="#">Haq et al. (2021)</a>
<i>Artemisia stechmanniana</i> Besser	Subshrub	Perennial	Kohistan, KPK	<a href="#">Amin et al. (2024)</a>
<i>Artemisia stricta</i> Edgew.	Herb	Annual or biennial	Deosai Astore, GB	<a href="#">Khan (2004)</a>

			Muzaffarabad, AJK	Hayat <i>et al.</i> (2009c,d)
			Muzaffarabad, AJK	Hayat <i>et al.</i> (2010a,b)
			Muzaffarabad, AJK	Malik and Hayat (2019)
<i>Artemisia tangutica</i> Pamp.	Herb	Perennial	Hunza, GB	Hayat <i>et al.</i> (2009b,c)
			Hunza, GB	Hayat <i>et al.</i> (2010a,b)
			Naran, KPK	Mahmood T <i>et al.</i> (2011)
			Shugran Mansehra, KPK	Mannan <i>et al.</i> (2010)
			Hunza, GB	Malik and Hayat (2019)
<i>Artemisia tecti-mundi</i> Podlech	Shrub	Perennial	Chitral, KPK	Malik and Hayat (2019)
<i>Artemisia tournefortiana</i> Rchb.	Herb	Annual	Deosai Astore, GB	Khan (2004)
			Murree Hills, Rawalpindi, Punjab	Hayat <i>et al.</i> (2009b,c)
			Murree Hills, Rawalpindi, Punjab	Hayat <i>et al.</i> (2010a,b)
			Ayubia, KPK	Mahmood T <i>et al.</i> (2011)
			Shigar Valley Skardu, GB	Hussain <i>et al.</i> (2019a,b,c)
			Naltar, Gilgit, GB	Malik and Hayat (2019)
			Shigar Valley, Skardu, GB	Hussain <i>et al.</i> (2023)
<i>Artemisia trichophylla</i> Wall.ex DC.	Herb	Annual or biennial	Dir Kohistan, KPK	Jan <i>et al.</i> (2009)
<i>Artemisia turanica</i> Krasch.	Shrub	Unknown	Naltar, Gilgit, GB	Hayat <i>et al.</i> (2009c,d)
			Naltar, Gilgit, GB	Hayat <i>et al.</i> (2010a,b)
			Naltar, Gilgit, GB	Malik and Hayat (2019)
<i>Artemisia vachanica</i> Krasch. ex Poljakov	Subshrub	Perennial	Chilas, GB	Malik and Hayat (2019)
<i>Artemisia verlotiorum</i> Lamotte	Herb	Perennial	Bubar Ghizer, GB	Hussain <i>et al.</i> (2020a)
			Bubar Ghizer, GB	Hussain <i>et al.</i> (2020c)
			Sukamaidan, Skardu, GB	Hussain <i>et al.</i> (2023)
<i>Artemisia vestita</i> Wall.	Subshrub	Perennial	Soon Valley, Jahlum, Punjab	Hayat <i>et al.</i> (2009c,d)
			Soon Valley, Jahlum, Punjab	Hayat <i>et al.</i> (2010a,b)
			Galyat, KPK	Mannan <i>et al.</i> (2010)
			Soon Valley, Jahlum, Punjab	Malik and Hayat (2019)
<i>Artemisia vulgaris</i> L.	Herb	Perennial	Utror-Gabral Valleys, Upper Swat, KPK	Hamayun <i>et al.</i> (2003)
			Gokand, Buner KPK	Khan <i>et al.</i> (2003)
			Karachi, Sindh	Khan and Gilani (2009)
			Swat, KPK	Hamayun <i>et al.</i> (2006a)
			Gilgit, GB	Afzal <i>et al.</i> (2009)
			Pearl Valley, Mutyal Mara, AJK	Hayat <i>et al.</i> (2009a,b,c)

			Swat, KPK	Ashraf <i>et al.</i> (2010)
			Pearl Valley, Mutyal Mara, AJK	Hayat <i>et al.</i> (2010a,b)
			Kalam Swat, KPK	Mannan <i>et al.</i> (2010)
			Dir Kohistan, KPK	Hazrat <i>et al.</i> (2011)
			Rawalakot, AJK	Mahmood T <i>et al.</i> (2011)
			Miandam Valley, Swat KPK	Sher <i>et al.</i> (2011)
			Kurram Agency, KPK	Hussain <i>et al.</i> (2012)
			Chakesar Valley, Shangla, KPK	Shah M and Hussain (2012)
			Bagh, AJK	Shaheen <i>et al.</i> (2012)
			Naran, KPK	Khan <i>et al.</i> (2013)
			ND	Nadeem <i>et al.</i> (2013)
			Central Punjab	Zereen <i>et al.</i> (2013)
			Galiyat, KPK	Zia-ur-Rehman <i>et al.</i> (2014)
			Dir Lower, KPK	Ahmad <i>et al.</i> (2015)
			Malakand, KPK	Sher <i>et al.</i> (2015)
			Swat, KPK	Shah SA <i>et al.</i> (2016)
			Kel Village Neelum Valley, AJK	Ahmad <i>et al.</i> (2017)
			Bajaur Agency, FATA	Aziz <i>et al.</i> (2017)
			Swat, KPK	Ali A <i>et al.</i> (2018)
			Mosammina Malakand, KPK	Ullah and Bibi (2018)
			Dera Ismail Khan, KPK	Zain-ul-Abideen <i>et al.</i> (2018)
			Dhirkot, AJK	Farooq <i>et al.</i> (2019)
			Shishkat Hunza-Nagar, GB	Hussain <i>et al.</i> (2019a,b,c)
			Pearl Valley, Mutyal Mara, AJK	Malik and Hayat (2019)
			Harighal, AJK	Amjad <i>et al.</i> (2020)
			Shishkat, Hunza-Nagar, GB	Hussain <i>et al.</i> (2020a)
			Buner, KPK	Sulaiman <i>et al.</i> (2020)
			Sudhnoti, AJK	Khan <i>et al.</i> (2021)
			Bagh, AJK	Maqsood <i>et al.</i> (2022)
			Haripur, KPK	Siddique <i>et al.</i> (2022)
			Ata Abad, Hunza-Nagar, GB	Hussain <i>et al.</i> (2023)
			Khuiratta, AJK	Aftab <i>et al.</i> (2023)
			<u>Dir Lower, KPK</u>	<u>Irfan <i>et al.</i>, (2023)</u>
			Surghar range, KPK	Rahim <i>et al.</i> (2023)

			Punjab	Zareef <i>et al.</i> (2023)
			Musk Deer National Park, Neelum Valley, AJK	Hussain M <i>et al.</i> , (2024)
			Sudhnoti, AJK	Ishtiaq <i>et al.</i> (2024)
			Bhimber, AJK	<u>Khanum <i>et al.</i> (2024)</u>
			Sakhra Valley, Swat, KPK	Shah <i>et al.</i> (2024)

AJK = Azad Jammu and Kashmir, FATA = Federaly Administered Tribal Areas, GB = Gilgit-Baltistan, KPK = Khyber Pakhtunkhwa, ND = not defined. The botanical names and authorities, growth habits and life forms of maximum species were confirmed from The Plants of the World Online (POWO, [2025](#)).

Despite this progress, the native status of several *Artemisia* species is still ambiguous, particularly those reported from habitats or regions with long histories of human-mediated plant movement. Inconsistencies between floristic treatments further highlight unresolved taxonomic issues and emphasize the need for integrative approaches combining field surveys, herbarium revision and molecular verification.

In synthesis, Pakistan's *Artemisia* diversity mirrors global ecological and evolutionary patterns associated with altitude, aridity and climatic variability, while also revealing region-specific research biases and taxonomic uncertainties. The observed increase in *Artemisia* species from 38 to 66 species may be an outcome of enhanced scientific scrutiny or may be an expanded checklist of the genus in Pakistan. It may reflect systematic ethnobotanical surveys, improved regional coverage and advancements in taxonomic tools, including molecular techniques and better resolution of species complexes. In the global context, *Artemisia* diversity has increased following the re-evaluation of morphologically similar taxa and the recognition of cryptic species. Future research must prioritize underexplored regions, resolve native versus introduced status, and integrate molecular and ecological data to fully understand the evolutionary dynamics of *Artemisia* in Pakistan.

### Growth Habit of *Artemisia* Species Reported in Pakistan

Habit is the external appearance of the plant (Font Quer 2001; Vázquez-Sánchez *et al.* 2012) showing the growth pattern. Plants having different growth habits may have differences in their stem stiffness related to the stem lignification (Isnard *et al.* 2012). In short, habits of plants can be distinguished by anatomy of plant stem, for example, herbs are plants without woody tissue at any level of their aerial stems (Eiten 1991; Mitscher 2007) valued for its savory, medicinal or aromatic potentials (Mitscher 2007) and shrubs are the plants with woody stem. Plants with the lianous growth habit present irregular vessels dimorphism, cambial growth and plentiful unlignified parenchyma (Angyalossy *et al.* 2014). Shrubs and trees self-supporting limitations cause development of the xylem with abundant longer axial elements and fibers (Rowe & Speck 2004).

Regarding the growth habit of 66 *Artemisia* species reported in Pakistan, the highest prevailing growth habit was herb (34 species, 51.51%). Shrub (15 species, 22.72%) was the second dominant life form of *Artemisia* species reported in Pakistan. Subshrubs (9 species, 13.63%) were the least dominant life forms of the *Artemisia* species. The growth habit was unknown for only one species as shown in Figure 3a.

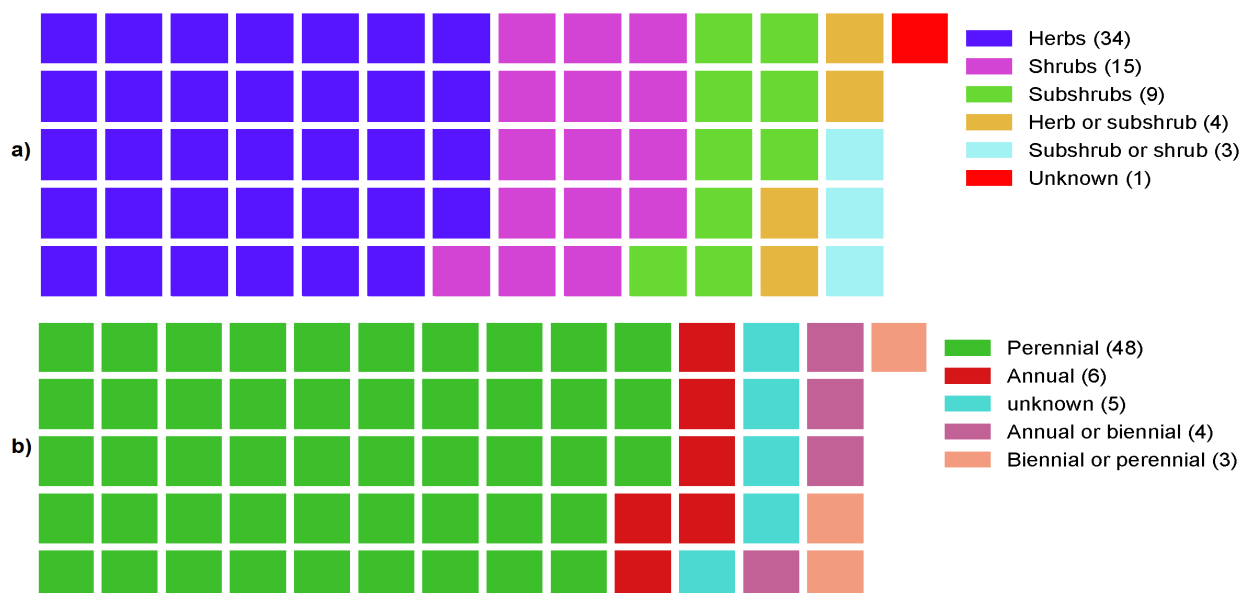


Figure 3. a) Growth habit and b) life cycle of *Artemisia* species reported in Pakistan.

The vastly governing growth habit of 34 *Artemisia* species reported in Pakistan was herb, hence the majority of the species due to being herb could be perennial or annual (He *et al.* 2016). Because herbs use environment differently and factors that alter the ecosystem functions are also different in herbs (Gómez-Aparicio 2009). The prevalent habit as herbs in *Artemisia* species in Pakistan is also evident for other medicinally important plants (Muthu *et al.* 2006; Tugume & Nyakoojo 2019; Nafeesa *et al.* 2021; Mekonnen *et al.* 2022; Hussain 2024; Hussain W *et al.* 2024; Kudamba *et al.* 2024; Asad *et al.* 2025) that could be due to some environmental factors, the type of soil (Nan *et al.* 2022) or the phytoconstituents present (Uprety *et al.* 2012). The herbs could be used easily in herbal recipes and obtained effortlessly from the natural territories (Hassan &

Gafoor, 2020; Ali & Marwat 2022). The next leading growth habit of *Artemisia* plants was shrub (15 species, 22.72%). For a lot of medicinal plants described previously in herbal remedies, shrub was also described as the prevailing growth habit (Alebie *et al.* 2017; Esubalew *et al.* 2017; Megersa *et al.* 2019; Tugume & Nyakoojo 2019). It was found that the accessibility and wide practice of shrubs in medicine is due to their capability to stand against stress conditions and seasonal deviations (Maroyi 2011).

The predominance of *Artemisia* species as herbs in Pakistan can be attributed to a combination of ecological adaptability to harsh environments, efficient reproductive strategies, favorable morphological traits and evolutionary changes that have shaped their growth form. The herbaceous nature of most *Artemisia* species enables them to thrive in Pakistan's diverse and challenging habitats, from the alpine regions to the arid lowlands, ensuring their survival and ecological success. This herbaceous dominance also reflects the adaptability and resilience of the genus, making it an important component of the Pakistani flora.

### **Life Cycle of *Artemisia* Species Reported in Pakistan**

The terrestrial plants can be categorized into two main types based on their life cycles such as annual and perennial (Friedman 2020). This division symbolizes the most key aspects of plants and exemplifies the inherent trade-offs between survival, reproduction and the attainment of seedling (Salguero-Gómez *et al.* 2016; Friedman 2020). The plants fall under the annual category reproduce once and complete life cycle in one growing season, but plants under perennial category live for more than one year and often have ability to reproduce repeatedly. The evolutionary changes imitated in these approaches manifest in a number of functional features of plants like root (Roumet *et al.* 2006) and leaf characters (Garnier & Vancaeyzeele 1994), genome features (Rice *et al.* 2019), invasiveness (Murray *et al.* 2002; Funk *et al.* 2016) and community stability (Grman *et al.* 2010) that affect the ecosystem (Glover *et al.* 2010; Vico *et al.* 2016). For example, by allotting more resources belowground, perennial plants store organic carbon, decrease erosion and have advanced water and nutrients utilization potentials (Glover *et al.* 2016; Vico *et al.* 2016; Kreitzman *et al.* 2020; Ledo *et al.* 2020).

Out of the 66 *Artemisia* species reported in Pakistan, 48 species (72.72%) were perennial, 6 species (9.09%) were annual, 4 species (6.06%) were either annual or biennial, and 3 species (4.54%) were either biennial or perennial. Additionally, the life cycle of 5 species (7.57%) remains unknown as depicted in Figure 3b. In the monocarpic stage of annual plant's life cycle, the entire apical meristems undertake transition to flowering stage concurrently. However, annuals only flower in the summer and spring and then stop further growth. In the fall season, perennials start vegetative growth again. Perennials have polycarpy (multiple flowering and fruit generating cycles) and they are different from annuals in their reproductive growth. In comparison to the perennial plants, annual plants can only progress floral and inflorescence meristems (Tan & Swain 2006). The perennials can bloom for many seasons and produce new flowers every year due to their polycarpic life schemes. The plants juvenile phase spreads from the germination of seed to the non receptive seedlings first flowering (Albani & Coupland 2010). The prevalence of *Artemisia* species as perennials in Pakistan could be due to their ecological adaptations to various environmental conditions. The perennial life form may provide these species with a survival advantage through deep root systems, regenerative growth and extended reproductive cycles, all of which contribute to their resilience in arid and alpine habitats. The ability of *Artemisia* species to persist through multiple seasons without requiring annual seed regeneration enhances their ecological resilience, thereby reinforcing their significance in the flora of Pakistan.

### **Region and Species Wise Reported Studies on *Artemisia* in Pakistan**

*Artemisia* species were highly studied from the Gilgit-Baltistan (223 reports) and KPK (207 reports) regions following Punjab (55 reports) and AJK (52 reports), while minimum studies were reported on *Artemisia* from Balochistan (16 reports), FATA (8 reports), Islamabad (8 reports) and Sindh (3 reported). There were 16 reports where the details of species locality were not defined (Figure 4, Table 2).

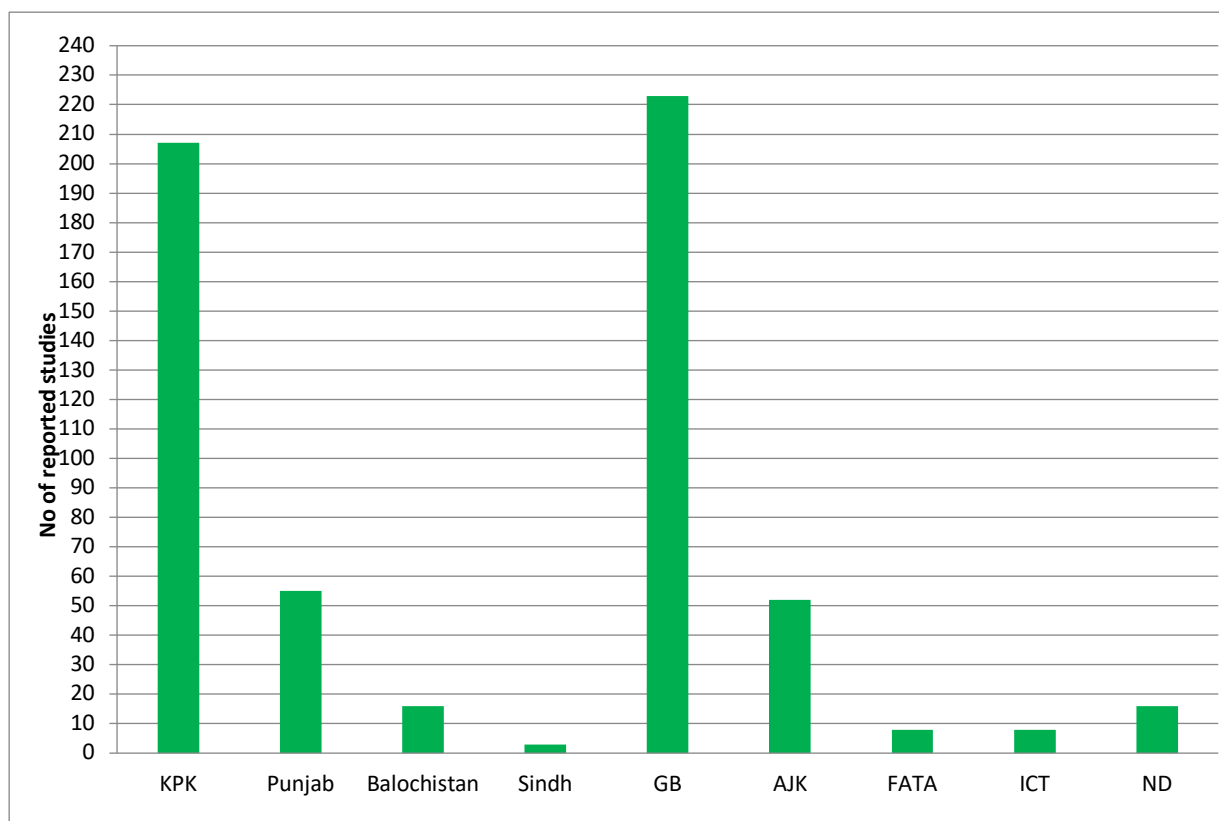


Figure 4. Region wise distribution of number of reported studies on *Artemisia* species from Pakistan based on the data from Table 2. ND = Not defined

Gilgit-Baltistan region of Pakistan has unique climate, latitude, longitude and altitude with dry and rigid mountains. Due to difference in climate, it has rare and unique system of bio-diversity and have distinct ethno-botanically important flora (Awan *et al.* 2013). Due to the exclusive ecological conditions, the northern areas of Pakistan specifically host many species of the genus *Artemisia* with medicinal significance (Ashraf *et al.* 2010). Both the Gilgit-Baltistan and KPK regions have a strong folk traditional use of *Artemisia* for herbal remedies, encouraging more studies on the species. Figure 5 shows the number of reported studies based on individual *Artemisia* species from Pakistan. *A. scoparia* was the most frequently reported, with 83 studies (35 from KPK, 14 from Punjab, 12 from GB, 5 from Islamabad, 4 from FATA, 1 from Balochistan, 1 from Sindh and 1 with undefined locality). It was followed by *A. absinthium* with 52 reports (23 from KPK, 20 from GB, 3 from Punjab, 3 from FATA, 2 from AJK, and 1 with undefined locality), *A. maritima* with 51 reports (22 from KPK, 24 from GB, 3 from AJK, 1 from Balochistan, and 1 with undefined locality), *A. vulgaris* with 49 reports (22 from KPK, 16 from AJK, 6 from GB, 2 from Punjab, 1 from FATA, 1 from AJK, and 1 with undefined locality), and *A. brevifolia* with 35 reports (17 from KPK, 13 from GB, 3 from Punjab, 1 from Balochistan, and 1 from Islamabad).

The number of reports for other *Artemisia* species includes: *A. rutifolia* Steph with 18 reports (13 from GB and 5 from KPK), *A. santalinifolia* with 17 reports (12 from GB and 4 from KPK), *A. dubia* with 16 reports (8 from KPK, 4 from GB, 3 from Punjab and 1 with undefined locality), *A. indica* with 15 reports (8 from GB, 7 from KPK), *A. sieversiana* with 14 reports from GB, *A. japonica* with 14 reports (6 from Punjab, 4 from KPK, 2 from AJK, 1 from GB and 1 with undefined locality), *A. annua* with 13 reports (8 from GB, 1 from KPK, 1 from Punjab, 1 from AJK, 1 from Islamabad and 1 with undefined locality), *A. biennis* with 13 reports (5 from Punjab, 4 from KPK and 4 from GB), *A. roxburghiana* Wall with 13 reports (5 from Punjab, 4 from KPK, 2 from GB, 1 from Islamabad and 1 with undefined locality), *A. tournefortiana* with 11 reports (6 from GB, 4 from Punjab, and 1 from KPK), *A. herba-alba* 10 reports (6 from GB, 4 from Balochistan), and *A. persica* with 10 reports (7 from KPK, 1 from Balochistan, 1 from AJK and 1 from GB). The remaining *Artemisia* species were reported with fewer than 10 reports from various regions across Pakistan

Table 2. Number of region wise reported studies on *Artemisia* species in Pakistan based on data from Table 1.

<i>Artemisia</i> spp.	KPK	Punjab	Balochistan	Sindh	GB	AJK	FATA	ICT	ND	Total
<i>A. absinthium</i>	23	3	0	0	20	2	3	0	1	52
<i>A. amygdalina</i>	5	0	0	0	0	0	0	0	0	5
<i>A. annua</i>	1	1	0	0	8	1	0	1	1	13
<i>A. arborescens</i>	0	0	0	0	1	0	0	0	0	1
<i>A. argyi</i>	0	0	0	0	1	0	0	0	0	1
<i>A. austriaca</i>	0	0	0	0	4	0	0	0	0	4
<i>A. biennis</i>	4	5	0	0	4	0	0	0	0	13
<i>A. bigelovii</i>	1	0	0	0	0	0	0	0	1	2
<i>A. brevifolia</i>	17	3	1	0	13	0	0	1	0	35
<i>A. bushiriensis</i>	0	0	0	0	1	0	0	0	0	1
<i>A. campestris</i>	0	0	0	0	3	0	0	0	0	3
<i>A. capillaris</i>	0	0	0	0	1	0	0	0	0	1
<i>A. chamaemelifolia</i>	0	0	0	0	7	0	0	0	0	7
<i>A. chitralensis</i>	1	0	0	0	0	0	0	0	0	1
<i>A. chinensis</i>	0	0	0	0	1	0	0	0	0	1
<i>A. cina</i>	1	0	0	0	0	0	0	0	0	1
<i>A. desertorum</i>	1	0	0	0	3	0	0	0	0	4
<i>A. dracunculus</i> L.	0	0	0	0	2	1	0	0	1	4
<i>A. dracunculus</i> var. <i>Persica</i> .	0	0	0	0	0	1	0	0	0	1
<i>A. dubia</i>	8	3	0	0	4	0	0	0	1	16
<i>A. elegantissima</i>	0	0	0	0	0	3	0	0	0	3
<i>A. fragrans</i>	3	0	0	0	2	0	0	0	1	6
<i>A. freitagii</i>	0	0	1	0	0	0	0	0	0	1
<i>A. glacialis</i>	0	0	0	0	1	0	0	0	0	1
<i>A. glanduligera</i>	1	0	0	0	0	0	0	0	0	1
<i>A. gmelinii</i>	1	0	0	0	11	0	0	0	0	12
<i>A. herba-alba</i>	0	0	4	0	6	0	0	0	0	10
<i>A. incisa</i>	3	0	0	0	0	0	0	0	0	3
<i>A. indica</i>	7	0	0	0	8	0	0	0	0	15
<i>A. japonica</i>	4	6	0	0	1	2	0	0	1	14
<i>A. kurramensis</i>	7	0	0	0	0	0	0	0	1	8
<i>A. laciniata</i>	0	0	0	0	3	0	0	0	0	3
<i>A. leucotricha</i>	0	0	0	0	3	0	0	0	0	3

<i>A. macrocephala</i>	2	0	0	0	3	2	0	0	1	8
<i>A. maritima</i>	22	0	1	0	24	3	0	0	1	51
<i>A. minor</i>	0	0	0	0	0	1	0	0	0	1
<i>A. montana</i>	0	0	0	0	1	0	0	0	0	1
<i>A. moorcroftiana</i>	2	1	0	0	0	2	0	0	1	6
<i>A. oliveriana</i>	0	0	2	0	0	0	0	0	1	3
<i>A. parviflora</i>	8	0	0	0	0	0	0	0	0	8
<i>A. persica</i>	7	0	1	0	1	1	0	0	0	10
<i>A. pontica</i>	0	0	0	0	1	0	0	0	0	1
<i>A. quettensis</i>	0	0	3	0	0	0	0	0	0	3
<i>A. roxburghiana</i> Wall	4	5	0	0	0	2	0	1	1	13
<i>A. roxburghiana</i> var <i>gratae</i>	0	1	0	0	0	0	0	0	0	1
<i>A. rutifolia</i> Steph	5	0	0	0	13	0	0	0	0	18
<i>A. rutifolia</i> var. <i>altaica</i>	0	0	0	0	3	0	0	0	0	3
<i>A. rutifolia</i> var. <i>ruoqiagensis</i>	0	0	0	0	1	0	0	0	0	1
<i>A. salsoloides</i>	0	1	0	0	0	0	0	0	0	1
<i>A. santolinifolia</i>	4	0	0	0	12	0	0	0	1	17
<i>A. scentonema</i>	1	0	0	0	0	0	0	0	0	1
<i>A. scoparia</i>	35	14	1	1	12	10	4	5	1	83
<i>A. sieberi</i>	0	1	1	0	1	0	0	0	0	3
<i>A. sieversiana</i>	0	0	0	0	14	0	0	0	0	14
<i>A. stenocephala</i>	0	0	1	0	3	0	0	0	0	4
<i>A. stechmanniana</i>	1	0	0	0	0	0	0	0	0	1
<i>A. stricta</i>	0	0	0	0	1	5	0	0	0	6
<i>A. tangutica</i>	2	0	0	0	5	0	0	0	0	7
<i>A. tecti-mundi</i>	1	0	0	0	0	0	0	0	0	1
<i>A. tournefortiana</i>	1	4	0	0	6	0	0	0	0	11
<i>A. trichophylla</i>	1	0	0	0	0	0	0	0	0	1
<i>A. turanica</i>	0	0	0	0	5	0	0	0	0	5
<i>A. vachanica</i>	0	0	0	1	0	0	0	0	0	1
<i>A. verlotiorum</i>	0	0	0	0	3	0	0	0	0	3
<i>A. vestita</i>	1	5	0	0	0	0	0	0	0	6
<i>A. vulgaris</i>	22	2	0	1	6	16	1	0	1	49
<b>Total</b>	<b>207</b>	<b>55</b>	<b>16</b>	<b>3</b>	<b>223</b>	<b>52</b>	<b>8</b>	<b>8</b>	<b>16</b>	

AJK = Azad Jammu and Kashmir, FATA = Federaly Administered Tribal Areas, GB = Gilgit-Baltistan, ICT = Islamabad Capital Territory, KPK = Khyber Pakhtunkhwa

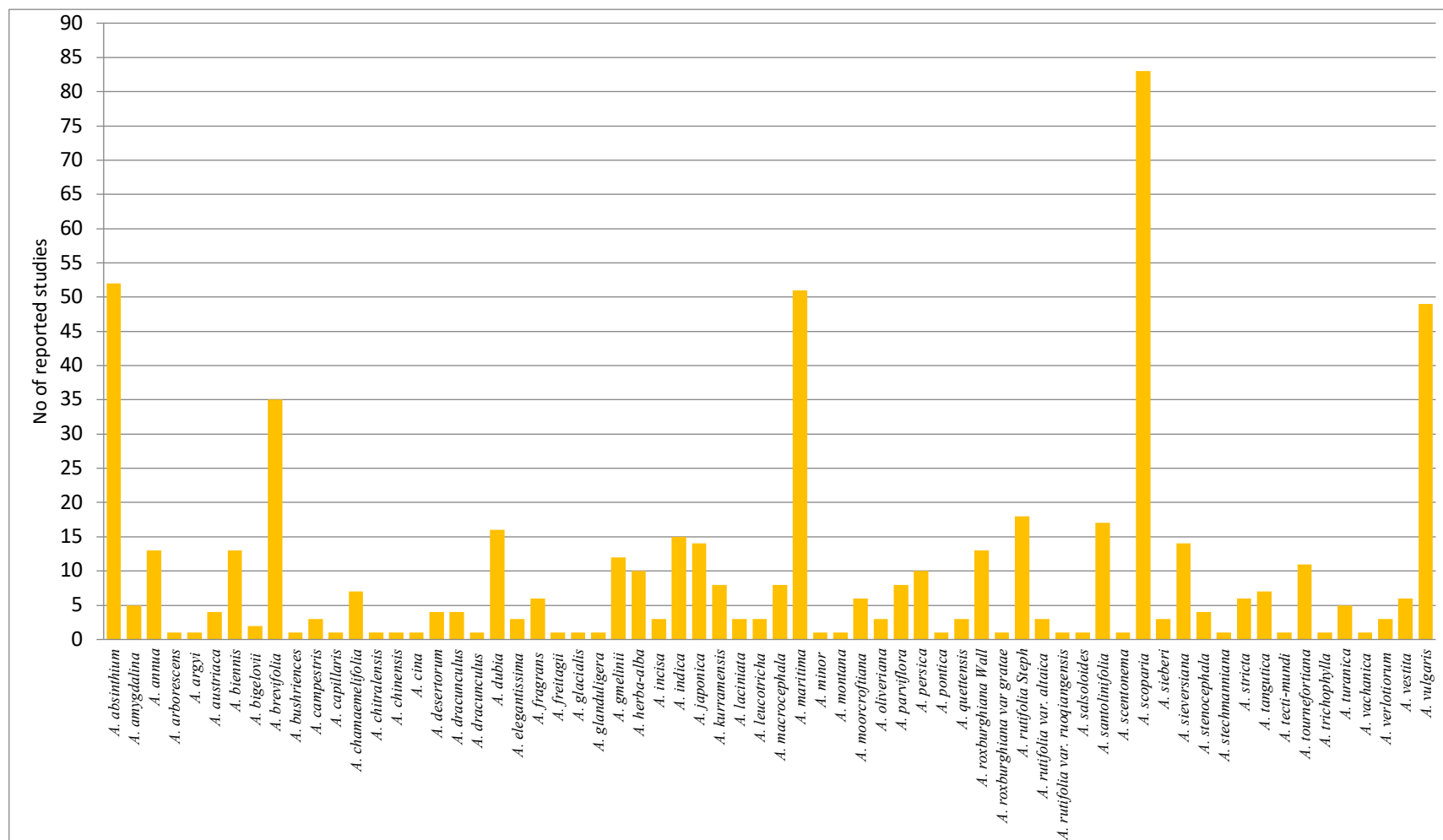


Figure 5. Species wise distribution of number of reported studies on *Artemisia* species from Pakistan based on the data from Table 2.

## Rare *Artemisia* Species Reported in Pakistan

In nature, species of various life forms vary significantly in their prevalence (McGill *et al.* 2007); however, the biological aspects of variations are still not well understood. Rare species are characterized normally by their limited geographical distribution, narrow habitat specialization or low local abundance (Rabinowitz 1981). It has been found that more than one third plant species are rare or very rare (Enquist *et al.* 2019). In this regard, plant species show historically continuing rarity pattern and commonness independent of current anthropogenic effects (Enquist *et al.* 2019). Even though, having inadequate representation in communities, rare species are significant for the ecosystem in various aspects including the resistance to biological invasions (Lyons & Schwartz 2001), cycling of nutrients (Theodose *et al.* 1996) and trophic dynamics (Bracken & Low 2012). Rare species are also thought to be the biodiversity and conservation indicators (Zavaleta & Hulvey 2004; Lawler *et al.* 2003). Examining the evolutionary and ecological causes underlying species rarity may advance ecological theory and could be beneficial in conservation (Bevill & Louda 1999), particularly in the perspective of rapid global change (Mouillot *et al.* 2013).

Based on the compiled data, several *Artemisia* species were reported only from specific localities in Pakistan (Figure 6). For instance, *A. argyi* was only reported in the Gilgit-Baltistan region (Hussain *et al.* 2019a,b), *A. austriaca* was found exclusively in the Bagrote valley of Gilgit-Baltistan (Hussain *et al.* 2019a,b,c, 2020a), *A. chamaemelifolia* was reported in both the Bagrote and Skardu regions of Gilgit-Baltistan (Hussain *et al.* 2019a,b,c, 2020a,b, 2023), *A. chinensis* was found only in Skardu, Gilgit-Baltistan (Hussain 2022) and *A. arborescens* was reported solely in Astore region of Gilgit-Baltistan (Hussain *et al.* 2019a). Similarly, *A. amydaliana* was reported only in the Mansehra region of KPK (Hayat *et al.* 2009a,b,c, 2010a,b; Malik & Hayat 2019), *A. bigelovi* in the Laspur Valley, Chitral, KPK (Wali S *et al.*, 2019), *A. dracunculus* var. *persica* in Rawalakot, AJK (Mannan *et al.* 2010), *A. bushiriensis* in Soost, Gilgit-Baltistan (Mannan *et al.* 2010) and *A. glacialis* in the Diamir district of Gilgit-Baltistan (Wali R *et al.* 2019).

Moreover, *A. chitralensis* was only reported in the Utak region of Chitral KPK (Malik & Hayat 2019), *A. cina* in Lower Dir region of KPK (Irfan *et al.* 2023), *A. elegantissima* in Pirchanasi, Muzaffarabad AJK (Rashid *et al.*, 2014) *A. freitagii* in Quetta Balochistan (Malik & Hayat 2019), *A. glanduligera* in the Parachinar region of Kurram Agency, KPK (Malik & Hayat 2019), *A. laciniata* (Fahad & Bano 2012; Malik & Hayat 2019; Salim *et al.* 2019) and *A. leucotricha* in the Gilgit-Baltistan region (Hayat *et al.* 2009b, 2010a; Malik & Hayat 2019), *A. minor* in the Neelum Valley, AJK (Malik & Hayat 2019), *A. montana* in Shigar valley Skardu, Gilgit-Baltistan (Hussain *et al.* 2019b,c), *A. oliveriana* in Balochistan (Malik & Hayat 2019; Rehman *et al.* 2021), *A. parviflora* in Chitral, KPK (Ahmad S *et al.* 2006; Khan N *et al.* 2011; Shah SM & Hussain 2012; Hadi *et al.* 2014; Wali *et al.* 2021; Fazal & Badshah 2024; Ullah & Badshah 2024), *A. kurramensis* in Kurram Agency, KPK (Qazilbash 1950; Hayat *et al.* 2009b,c; Hayat *et al.* 2010a,b; Malik & Hayat 2019), *A. pontica* in the Bagrote Valley of Gilgit-Baltistan (Hussain *et al.* 2019c), *A. quettensis* in Mastung, Koh Marat, Kalat and Hazarganji, Balochistan (Bibi *et al.* 2014; Malik & Hayat 2019; Rehman *et al.* 2021), *A. roxburghiana* var. *gratae* in Murree Rawalpindi, Punjab (Mannan *et al.* 2010), *A. rutifolia* var. *altaica* (Krylov) in the Gilgit-Baltistan region (Hussain *et al.* 2019c, 2020a, 2023), *A. rutifolia* var. *ruoqiangensis* in Naltar Valley, Gilgit-Baltistan (Hussain *et al.* 2020a), *A. salsoloides* in the Murree Hills Rawalpindi, Punjab (Malik & Hayat 2019), *A. scentonema* in Chakesar Valley Shangla, KPK (Shah M & Hussain 2012), *A. sieversiana* in Gilgit-Baltistan (Khan & Khatoon 2008; Hayat *et al.* 2009b,c, 2010a,b; Mannan *et al.* 2010; Noor *et al.* 2012; Hyder *et al.* 2013; Bano *et al.* 2014b; Malik & Hayat 2019; Salim *et al.* 2019; Hussain *et al.* 2020a; Din *et al.* 2024b; Hussain A *et al.* 2024), *A. stechmanniana* in Kohistan, KPK (Amin *et al.* 2024), *A. tectimundi* in Chitral, KPK (Malik & Hayat 2019), *A. trichophylla* in Dir Kohistan, KPK (Jan *et al.* 2009), *A. turanica* in Naltar Gilgit-Baltistan (Hayat *et al.* 2009c,d, 2010ab; Malik & Hayat 2019), *A. vachanica* in Chilas, Gilgit-Baltistan (Malik & Hayat 2019) and *A. verlotiorum* was only reported in the Ghizer and Skardu regions of Gilgit-Baltistan (Hussain *et al.* 2020a,b, 2023).

The regional specificity of *Artemisia* species in Pakistan likely reflects a complex interplay of environmental factors like climatic conditions, altitude, soil characteristics and ecological relations. Each species appears to be adapted to unique conditions of its particular habitat, resulting in distinct distribution patterns across the country. Such ecological specialization enables *Artemisia* taxa to thrive in a wide range of environments from arid lowlands to cold, high-altitude mountainous regions. Understanding these distributional patterns is essential for advancing ecological knowledge and informing conservation strategies. In this context, species with highly restricted distributions and narrowly localized taxa should be regarded as high priority candidates for detailed field based investigations and subsequent evaluation under IUCN Red List criteria.



Table 3. Details of flowering period, habitat and distribution/native status of *Artemisia* species reported in Pakistan.

<i>Artemisia</i> spp.	Flowering period	Habitat	Distribution status in Pakistan			
			Native		Non-native, or may be invasive	NA
			Flora of Pakistan (FOP)	Plants of the World Online (POWO)		
<i>A. absinthium</i>	June-September	Temperate biome	✓	✓	--	--
<i>A. amygdalina</i>	July-September	Subalpine or subarctic biome	✓	✓	--	--
<i>A. annua</i>	August-September	Subtropical biome	✓	✓	--	--
<i>A. arborescens</i>	August-September	Subtropical biome	--	--	✓	--
<i>A. argyi</i>	July-October	Temperate biome	--	--	✓	--
<i>A. austriaca</i>	July-September	Temperate biome	--	--	✓	--
<i>A. biennis</i>	July-September	Temperate biome	✓	--	--	--
<i>A. bigelovii</i>	July-November	Temperate biome	--	--	✓	--
<i>A. brevifolia</i>	August-September	Temperate biome	✓	✓	--	--
<i>A. bushiriensis</i>	NA	NA	--	--	--	✓
<i>A. campestris</i>	July-September	Temperate biome	--	--	✓	--
<i>A. capillaris</i>	August-October	Temperate biome	✓	✓	--	--
<i>A. chamaemelifolia</i>	June-August	Temperate biome	--	--	✓	--
<i>A. chitralensis</i>	September	Temperate biome	✓	✓	--	--
<i>A. chinensis</i>	NA	Subtropical biome	--	--	✓	--
<i>A. cina</i>	August-October	Temperate biome	--	--	✓	--
<i>A. desertorum</i>	July-September	Temperate biome	✓	--	--	--
<i>A. dracunculus</i> L.	July-August	Temperate biome	✓	✓	--	--
<i>A. dracunculus</i> var. <i>Persica</i> .	NA	NA	--	--	--	✓
<i>A. dubia</i>	August-October	Temperate biome	✓	✓	--	--
<i>A. elegantissima</i>	July-August	Temperate biome	✓	✓	--	--
<i>A. fragrans</i>	July-August	Temperate biome	--	--	✓	--
<i>A. freitagii</i>	NA	Temperate biome	✓	✓	--	--
<i>A. glacialis</i>	July-September	Subalpine or subarctic biome	--	--	✓	--
<i>A. glanduligera</i>	NA	Temperate biome	✓	✓	--	--

<i>A. gmelinii</i>	August-October	Temperate biome	✓	✓	--	--
<i>A. herba-alba</i>	September-December	Subtropical biome	--		✓	--
<i>A. incisa</i>	August-September	Temperate biome	✓	✓	--	--
<i>A. indica</i>	August-October	Temperate biome	--	✓	--	--
<i>A. japonica</i>	July-September	Temperate biome	✓	✓	--	--
<i>A. kurramensis</i>	July-September	Temperate biome	✓	✓	--	--
<i>A. laciniata</i>	August-September	Temperate biome	✓	--	--	--
<i>A. leucotricha</i>	June-August	Temperate biome	✓	✓	--	--
<i>A. macrocephala</i>	June-August	Subalpine or subarctic biome	✓	✓	--	--
<i>A. maritima</i>	July-September	Temperate biome	--	--	✓	--
<i>A. minor</i>	June-September	Subalpine or subarctic biome	✓	--	--	--
<i>A. montana</i>	July-September	Temperate biome	--	--	✓	--
<i>A. moorcroftiana</i>	July-August	Subalpine or subarctic biome	✓	--	--	--
<i>A. oliveriana</i>	October-November	Temperate biome	✓	✓	--	--
<i>A. parviflora</i>	July-September	Temperate biome	--	✓	--	--
<i>A. persica</i>	June-September	Temperate biome	✓	✓	--	--
<i>A. pontica</i>	August-October	Temperate biome	--	--	✓	--
<i>A. quettensis</i>	May-November	Desert or dry shrubland biome	✓	✓	--	--
<i>A. roxburghiana</i> Wall	August-October	Temperate biome	✓	✓	--	--
<i>A. roxburghiana</i> var <i>grata</i>	NA	Temperate biome	--	--	✓	--
<i>A. rutifolia</i> Steph	June-August	Temperate biome	✓	✓	--	--
<i>A. rutifolia</i> var. <i>altaica</i>	June-August	Temperate biome	--	--	✓	--
<i>A. rutifolia</i> var. <i>ruoqiagensis</i>	June-August	Temperate biome	--	--	✓	--
<i>A. salsoloides</i>	July-September	Temperate biome	✓	--		--
<i>A. santolinifolia</i>	July-September	Temperate biome	✓	✓	--	--
<i>A. scentonema</i>	NA	NA	--	--	--	✓
<i>A. scoparia</i>	July-November	Temperate biome	✓	✓	--	--
<i>A. sieberi</i>	July-October	Temperate biome	✓	✓	--	--

<i>A. sieversiana</i>	July-August	Temperate biome	✓	✓	--	--
<i>A. stenocephala</i>	Late summer to early fall	Temperate biome	✓	✓	--	--
<i>A. stechmanniana</i>	NA	Temperate biome	--	✓	--	--
<i>A. stricta</i>	August-September	Temperate biome	✓	--	--	--
<i>A. tangutica</i>	NA	Temperate biome	--	--	✓	--
<i>A. tecti-mundi</i>	NA	Temperate biome	✓	✓	--	--
<i>A. tournefortiana</i>	July-October	Temperate biome	--	✓	--	--
<i>A. trichophylla</i>	July-September	Temperate biome	--	✓	--	--
<i>A. turanica</i>	June-September	Temperate biome	✓	✓	--	--
<i>A. vachanica</i>	August	Temperate biome	✓	✓	--	--
<i>A. verlotiorum</i>	July-September	Temperate biome	--	✓	--	--
<i>A. vestita</i>	August-October	Temperate biome	--	✓	--	--
<i>A. vulgaris</i>	August-November	Temperate biome	✓	✓	--	--

NA = Not available, Data obtained from Flora of Pakistan (<http://www.efloras.org>) (Ghafoor 2002) and Plants of the World online (POWO 2025), <https://powo.science.kew.org>

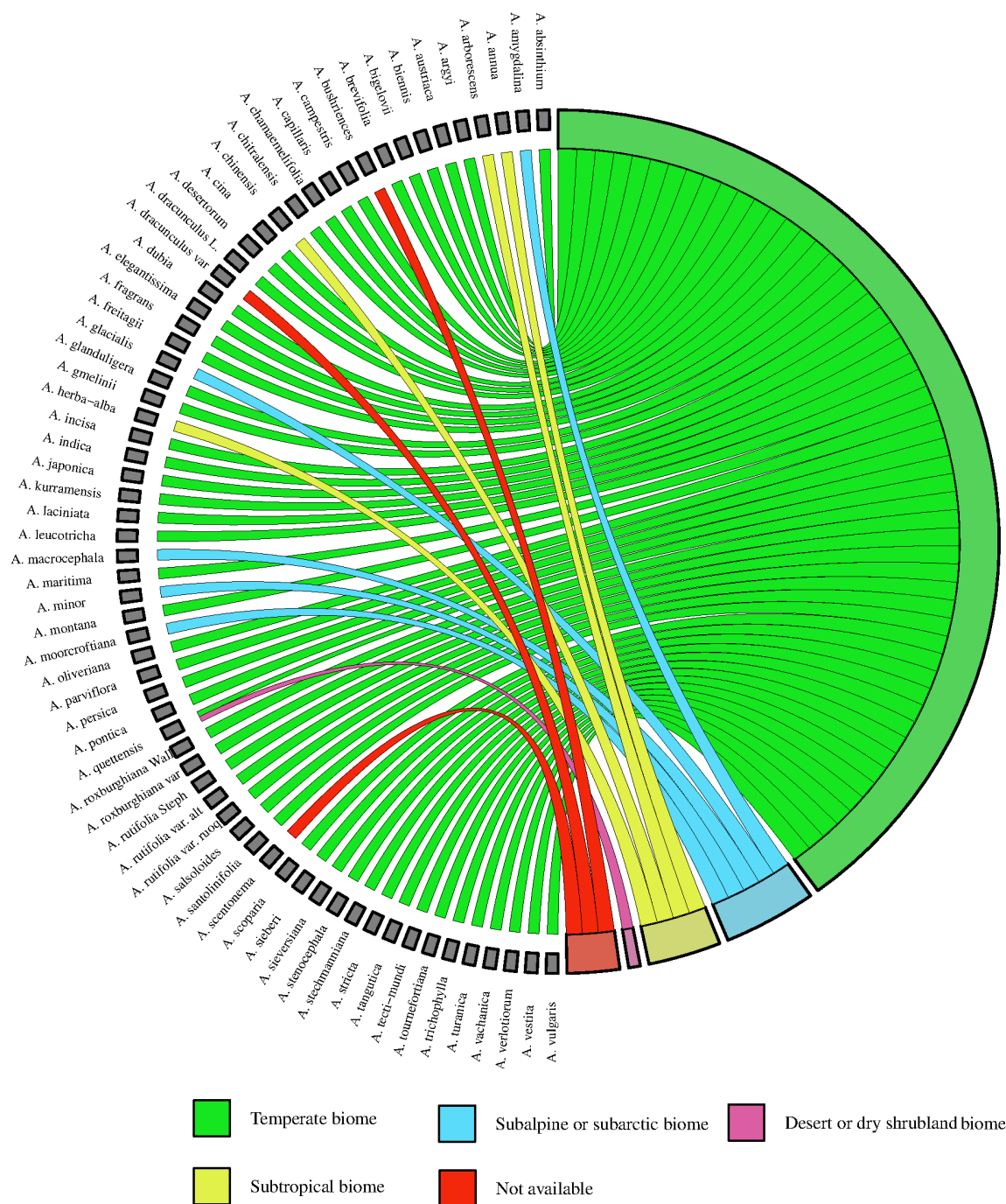


Figure 7. Percentage distribution of *Artemisia* species reported in Pakistan categorized by habitat (data obtained from Table 3). Chord plot drawn with SR Plot (Tang et al. 2023).

### Native Status of *Artemisia* Species in Pakistan

Data regarding the native status of *Artemisia* species in Pakistan was sourced from the *Flora of Pakistan* (Ghafoor 2002) and *Plants of the World Online* (POWO, 2025); because POWO ensures access to reliable, authoritative and up to date information on plant species. It offers comprehensive data on taxonomy, distribution, and conservation status maintained by a trusted botanical institution like The Royal Botanic Gardens, Kew, UK. The combined data in both sources mentioned 45 species as native to Pakistan, including *A. absinthium*, *A. amygdalina*, *A. annua*, *A. biennis*, *A. brevifolia*, *A. capillaris*, *A. chitralensis*, *A. desertorum*, *A. dracunculoides*, *A. dubia*, *A. elegantissima*, *A. freitagii*, *A. glanduligera*, *A. gmelinii*, *A. incisa*, *A. indica*, *A. japonica*, *A. kurramensis*, *A. laciniata*, *A. leucotricha*, *A. macrocephala*, *A. minor*, *A. moorcroftiana*, *A. oliveriana*, *A. parviflora*, *A. persica*, *A. quettensis*, *A. roxburghiana* Wall., *A. rutifolia* Steph., *A. salsoloides*, *A. santolinifolia*, *A. scoparia*, *A. sieberi*, *A.*

*sieversiana*, *A. stenocephala*, *A. stechmanniana*, *A. stricta*, *A. tecti-mundi*, *A. tournefortiana*, *A. trichophylla* (mentioned as synonym of *A. scoparia* in The Plants of the World Online), *A. turanica*, *A. vachanica*, *A. vestita*, *A. verlotiorum* and *A. vulgaris* (Table 3, Figure 8). The native status of remaining 21 *Artemisia* species in Pakistan is unknown or yet to be explored, however it is possible that these species could be invasive or migrants or introduced from the adjacent countries.

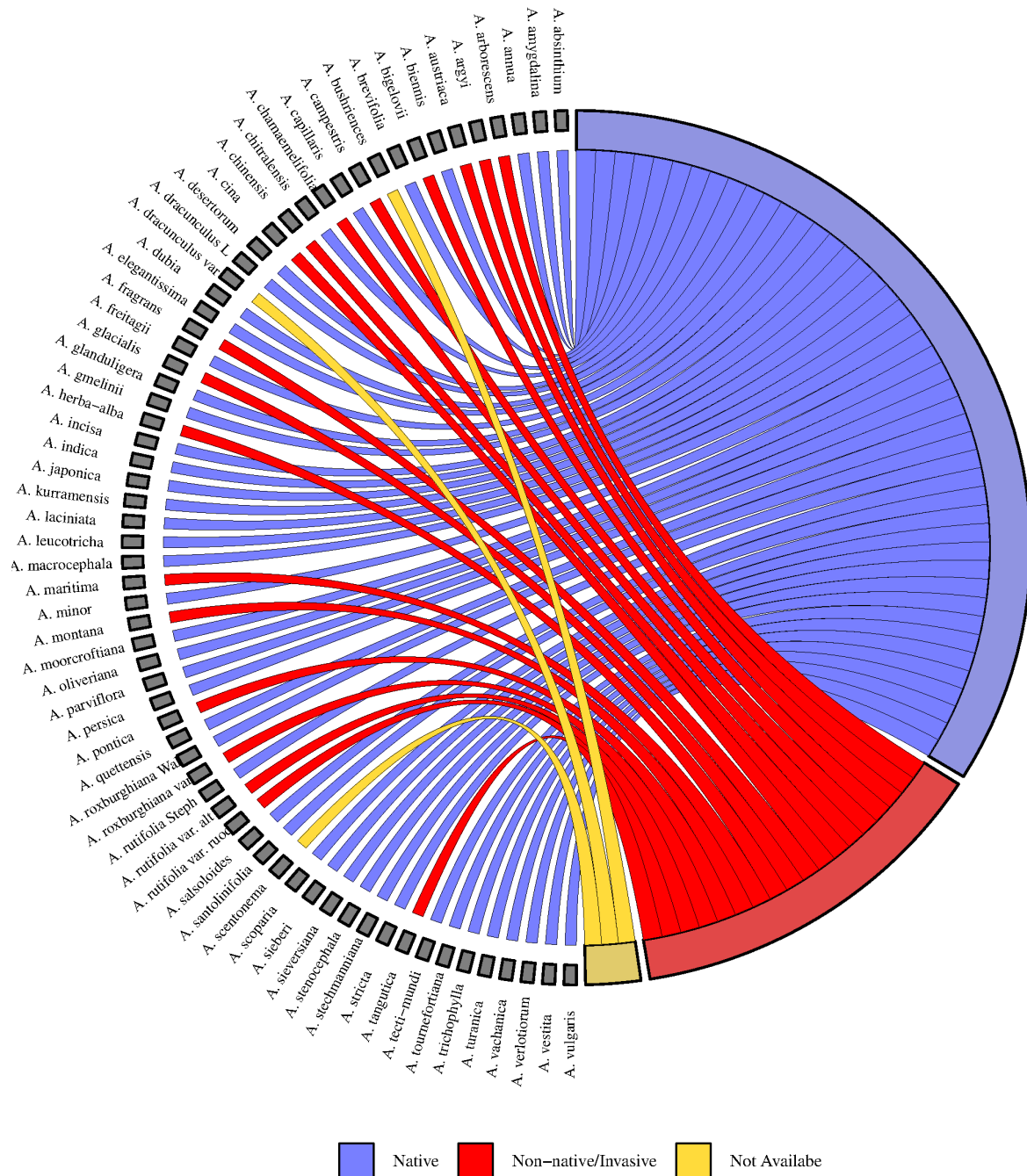


Figure 8. The distribution/native status of *Artemisia* species reported in Pakistan (data obtained from Table 3). Chord plot drawn with SR Plot (Tang *et al.* 2023).

Among the 45 native *Artemisia* species, 38 species were listed in both the *Flora of Pakistan* and the *Plants of the World Online* databases. Interestingly, 31 of these species are common across both sources including *A. absinthium*, *A. amygdalina*, *A. annua*, *A. brevifolia*, *A. capillaris*, *A. chitralensis*, *A. dracunculus L.*, *A. dubia*, *A. elegantissima*, *A. freitagii*, *A. glanduligera*,

*A. gmelinii*, *A. incisa*, *A. japonica*, *A. kurramensis*, *A. leucotrica*, *A. macrocephala*, *A. oliveriana*, *A. persica*, *A. quettensis*, *A. roxburghiana* Wall., *A. rutifolia* Steph., *A. santolinifolia*, *A. scoparia*, *A. sieberi*, *A. sieversiana*, *A. stenocephala*, *A. tecti-mundi*, *A. turanica*, *A. vachanica* and *A. vulgaris*.

However, discrepancies were observed for certain species. The Flora of Pakistan includes *A. biennis*, *A. desertorum*, *A. laciniata*, *A. minor*, *A. moorcroftiana*, *A. salsoloides* and *A. stricta*, whereas POWO lists *A. indica*, *A. parviflora*, *A. stechmanniana*, *A. tournefortiana*, *A. trichophylla*, *A. vestita* and *A. verlotiorum* reflecting differences in botanical documentation (Table 3, Figure 8). In cases of such discrepancies, species were retained if recognized in either source. POWO was followed for updated taxonomic status and nomenclature, while the Flora of Pakistan was used to support regional occurrence.

A native species is one that naturally occurs in a specific habitat and ecosystem of a region without the influence of direct or indirect human intervention (Richards 1998). Native plants are highly valued for their economic, ecological, genetic and aesthetic contributions as well as for their perceived intrinsic value as living organisms. *Artemisia* species may be native to Pakistan due to the region's diverse climates and ecosystems, which provide optimal conditions for these plants to flourish. The species may be well-suited to the country's varied landscapes, including mountains, plains and arid regions. Their ability to thrive in poor soils and endure dry conditions may allow them to naturally survive in Pakistan's environment.

Non-native species are categorized as either exotic or invasive, depending on their impact on the environment and local fauna and flora. Exotic species are those that are introduced to an area where they did not evolve, but they do not cause significant harm (Vitt & Caldwell 2014). Alien species that establish self-sustaining populations in the invaded area are known as naturalized species. Among these, invasive species are a subset that rapidly spread from their point of introduction and cause substantial ecological disruption (Blackburn *et al.* 2011). Some definitions reserve the term "invasive" for alien species that have negative environmental impacts (IUCN 2000). Invasive species are characterized by fast growth, widespread distribution, formation of self-sustaining populations, production of large numbers of reproductive offspring and the ability to thrive in a variety of habitats, including agricultural land, grasslands, wastelands, drylands and riparian zones (Chytrý *et al.* 2008; Pyšek *et al.* 2022). *Artemisia* species have the potential to become invasive in Pakistan due to their high adaptability, rapid growth and prolific reproduction, which enable them to spread quickly across various landscapes. In Pakistan, they often face fewer natural predators that would typically regulate their growth in their native environments. Additionally, some *Artemisia* species produce chemicals that inhibit the growth of surrounding plants, giving them a competitive edge. Their introduction sometimes for medicinal purposes, combined with Pakistan's favorable climate and soil conditions may allow them to flourish and out-compete native vegetation, disrupting local ecosystems. While many countries maintain databases of invasive alien plants, there is still a lack of comprehensive information, which hinders efforts to develop and enforce effective management policies (van Kleunen *et al.* 2015).

### Global Conservation Status of *Artemisia* Species

The global conservation status and population trends based on IUCN red list of threatened species and other sources for *Artemisia* species reviewed here are given in Table 4. According to the pertinent sources, out of 66 species, the conservation status of only 13 (20%) was available and the conservation status of remaining 53 species was not evaluated (NE) by any source. 6 *Artemisia* species viz *A. absinthium*, *A. biennis*, *A. campestris*, *A. dracunculus*, *A. laciniata* and *A. vulgaris* were declared least concern (LC) by various sources. 3 species (*A. arborescens*, *A. maritima* and *A. sieversiana*) were endangered (EN), 2 species (*A. amygdaliana* and *A. chamaemelifolia*) as critically endangered (CR) and 2 species (*A. herba-alba* and *A. chinensis*) were declared with threatened (TH) and/or near threatened (NT) status.

Table 4. Global conservation status of *Artemisia* species reported from Pakistan.

<i>Artemisia</i> spp.	Population trend	Conservation status	Reference
<i>A. absinthium</i>	Stable	LC	Ud Din <i>et al.</i> (2024)
<i>A. amygdalina</i>	NE	CR	Lone <i>et al.</i> (2015)
<i>A. annua</i>	NE	NE	NatureServe (2025)
<i>A. arborescens</i>	NE	EN	Riahi <i>et al.</i> (2022)
<i>A. argyi</i>	NE	NE	--
<i>A. austriaca</i>	NE	NE	--
<i>A. biennis</i>	Stable	LC	NatureServe (2025)
<i>A. bigelovii</i>	NE	NE	NatureServe (2025)

<i>A. brevifolia</i>	NE	NE	--
<i>A. bushiriensis</i>	NE	NE	--
<i>A. campestris</i>	Stable	LC	NatureServe (2025)
<i>A. capillaris</i>	NE	NE	--
<i>A. chamaemelifolia</i>	NE	CR	Petrova and Vladimirov 2009
<i>A. chitralensis</i>	NE	NE	--
<i>A. chinensis</i>	NE	NT	Flora of China (2011)
<i>A. cina</i>	NE	NE	--
<i>A. desertorum</i>	NE	NE	--
<i>A. dracunculus</i> L.	Stable	LC	NatureServe (2025)
<i>A. dracunculus</i> var. <i>Persica</i> .	NE	NE	--
<i>A. dubia</i>	NE	NE	--
<i>A. elegantissima</i>	NE	NE	--
<i>A. fragrans</i>	NE	NE	--
<i>A. freitagii</i>	NE	NE	--
<i>A. glacialis</i>	NE	NE	--
<i>A. glanduligera</i>	NE	NE	--
<i>A. gmelinii</i>	NE	NE	--
<i>A. herba-alba</i>	NE	TH	Aljayyash <i>et al.</i> (2018)
<i>A. incisa</i>	NE	NE	--
<i>A. indica</i>	NE	NE	--
<i>A. japonica</i>	NE	NE	--
<i>A. kurramensis</i>	NE	NE	--
<i>A. laciniata</i>	Stable	LC	NatureServe (2025)
<i>A. leucotricha</i>	NE	NE	--
<i>A. macrocephala</i>	NE	NE	--
<i>A. maritima</i>	NE	EN	Parihar <i>et al.</i> (2011)
<i>A. minor</i>	NE	NE	--
<i>A. montana</i>	NE	NE	--
<i>A. moorcroftiana</i>	NE	NE	--
<i>A. oliveriana</i>	NE	NE	--
<i>A. parviflora</i>	NE	NE	--
<i>A. persica</i>	NE	NE	--
<i>A. pontica</i>	NE	NE	--
<i>A. quettensis</i>	NE	NE	--
<i>A. roxburghiana</i> Wall	NE	NE	--
<i>A. roxburghiana</i> var. <i>gratae</i>	NE	NE	--
<i>A. rutifolia</i> Steph	NE	NE	--
<i>A. rutifolia</i> var. <i>altaica</i>	NE	NE	--
<i>A. rutifolia</i> var. <i>ruoqiagensis</i>	NE	NE	--
<i>A. salsoloides</i>	NE	NE	--
<i>A. santolinifolia</i>	NE	NE	--
<i>A. scentonema</i>	NE	NE	--
<i>A. scoparia</i>	NE	NE	NatureServe (2025)
<i>A. sieberi</i>	NE	NE	--
<i>A. sieversiana</i>	NE	EN	Ali <i>et al.</i> (2024)
<i>A. stenocephala</i>	NE	NE	--
<i>A. stechmanniana</i>	NE	NE	--
<i>A. stricta</i>	NE	NE	--
<i>A. tangutica</i>	NE	NE	--
<i>A. tecti-mundi</i>	NE	NE	--
<i>A. tournefortiana</i>	NE	NE	--
<i>A. trichophylla</i>	NE	NE	--
<i>A. turanica</i>	NE	NE	--

<i>A. vachanica</i>	NE	NE	--
<i>A. verlotiorum</i>	NE	NE	--
<i>A. vestita</i>	NE	NE	--
<i>A. vulgaris</i>	Stable	LC	Khela (2012)
	NE	NE	NatureServe (2025)

CR = critically endangered, EN = endangered, LC = least concern, NE = not evaluated, NT = near threatened, TH = threatened

According to Bachman *et al.* (2024), plants specifically the vascular plants with unassessed conservation status are more than 70%. The species conservation status in terms of their risk of extinction is an example of a basic vital metric which is difficult to measure and monitor. A broader evaluation of plants conservation status persisted as unresolved knowledge gap (Bachman *et al.* 2018; Nic Lughadha *et al.* 2020) despite of many efforts of the conservation communities (Sharrock *et al.* 2018). Such deficits and knowledge gaps in accomplishing plants conservation evaluations could be addressed by consulting the IUCN Red List of Threatened Species™ (IUCN 2012). For the 350,000 vascular plants, the up to date IUCN Red List (IUCN 2022) validated 62,666 species (18%) which were evaluated on the basis of morphology, geography and taxonomy (Nic Lughadha *et al.* 2020). To tackle human miscalculations in evaluation of specific species, a random sample for assessment should be selected following the Sampled Red List Index (Brummitt *et al.* 2015).

In Pakistan, due to loss of habitat, overuse and pollution, a huge number of species may be under threat. The PNCS (Pakistan's National Conservation Strategy) in collaboration with IUCN works and sets out conservation strategies for species conservation (PNCS 1991). Nevertheless, to achieve this, the role of native community is very crucial in conserving the natural resources through different strategies. Providing awareness to the local people about the biological diversity and conservation could preserve a vigorous ecosystem (Habibi 1997). The identification of 66 *Artemisia* species in Pakistan significantly increases implications for their conservation, as more species may require protection especially those that are rare to specific regions. It also opens up avenues for further ecological and pharmacological research as many *Artemisia* species have important medicinal, aromatic and ecological roles.

### Future Research Directions on *Artemisia*

A countrywide survey for the identification and documentation of all *Artemisia* species distributed in various regions of Pakistan is vital with particular focus on the Northeastern Pakistan. This will involve revisiting the areas where *Artemisia* species are known to grow including those where species status is unclear or unexplored. It would also be helpful to combine both local knowledge and scientific methods to generate a more precise and thorough record of the genus in Pakistan. Further research is needed to verify the native status of *Artemisia* species especially in relation to the divergences found in the Flora of Pakistan and Plants of the World Online databases. It will be essential to use molecular techniques and comprehensive field studies to establish clear native and non-native species classifications.

More research should focus on the ecological niches of *Artemisia* species in Pakistan. Understanding the specific environmental conditions and habitats that support these plants will help conserve them in their natural settings. Particular attention should be given to the four main habitats where *Artemisia* thrives, with a focus on factors such as soil type, climate, altitude and symbiotic plant communities. Given that only 13 *Artemisia* species have a known global conservation status, it is crucial to assess the remaining species. This could be achieved by collaborating with international conservation bodies like the International Union for Conservation of Nature (IUCN). National efforts should include a systematic evaluation of each species to determine its conservation priority and the impact of environmental threats. Since many *Artemisia* species are known for their medicinal properties, future studies should focus on their traditional uses across different regions of Pakistan, especially in rural or indigenous communities.

With the changing environmental conditions, certain species may become endangered or their ranges may shift. Understanding how temperature, precipitation and other climate factors influence *Artemisia* populations can inform conservation strategies and help predict future trends. Studies should focus on the genetic diversity within and among *Artemisia* species in Pakistan. Identifying genetically distinct populations can aid in the development of conservation breeding programs. This research would be particularly valuable for species at risk of extinction or with limited geographic distribution.

Efforts should be made to connect local researchers in Pakistan with global conservation and botanical networks. By collaborating with international research institutions and contributing data to global databases, Pakistan can play a key role

in the global understanding and conservation of *Artemisia* species. Raising awareness about the importance of *Artemisia* species, both ecologically and medicinally should be a priority in future research. Local communities should be engaged in conservation efforts, especially in areas where *Artemisia* species are under threat. Involving communities in sustainable harvesting practices and the protection of their natural habitats can contribute significantly to the long-term conservation of these species. By addressing these research directions, the knowledge gaps surrounding *Artemisia* species in Pakistan can be effectively managed, leading to better-informed conservation strategies, improved sustainability and enhanced utilization of these valuable plants.

## Conclusions

Based on the compiled data from literature, 66 *Artemisia* species have been reported across various regions of Pakistan with the highest numbers of studies from Gilgit-Baltistan and KPK. Of these, 45 species are mentioned as native to Pakistan in the the *Flora of Pakistan* and *Plants of the World Online* (POWO) databases while the status of majority of the species was not mentioned. The *Artemisia* species predominantly thrive in four main habitats. However, the global conservation status is only available for 13 species, with the status of 54 species still unassessed. The increase in reported species in Pakistan may reflect improved taxonomic resolution, expand geographic surveys and increased ethnobotanical research which may or may not be an expansion of the genus in Pakistan. The lack of comprehensive data on the distribution, native status and conservation of *Artemisia* in Pakistan limits not only national research but also hinders global efforts to understand and conserve the genus. Addressing this knowledge gap is crucial for advancing research, improving conservation strategies and sustainably utilizing these medicinally important species.

## Declarations

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