**Special Collection "Grasslands of Asia"**

**Type: Editorial**

# Advancing vegetation classification of grassland ecosystems across Asia: current status and way forward

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## Abstract

This editorial introduces the Special Collection "Grasslands of Asia" in Vegetation Classification and Survey, highlighting the urgent need for systematic vegetation classification across Asia's diverse grassland ecosystems. Despite their vast ecological, climatic, and cultural significance, Asian grasslands remain underrepresented in global vegetation studies. This gap results from uneven research capacities, methodological fragmentation, limited data accessibility, and complex geopolitical barriers. Grasslands across Asia, spanning natural types like steppes, savannas, and alpine meadows, as well as semi-natural ecosystems, face escalating threats including climate change, overgrazing, land-use changes, habitat fragmentation, and socio-political disruptions. Inspired by discussions at the inaugural Asian Grassland Conference in 2022 and the establishment of the Asian Regional Section of the International Association for Vegetation Science (IAVS), this Special Collection aims to promote standardized vegetation classification methods, enhance cross-regional data sharing, and foster international collaboration. Although only seven contributions from West and Middle Asia were ultimately included, they significantly advance the understanding of grassland typologies in these regions. Moving forward, coordinated efforts at local, regional, and continental scales, supported by platforms such as the Asian Regional Section of IAVS are essential. Strengthening vegetation classification frameworks and regional databases will bridge existing methodological gaps and provide critical support for conservation planning, sustainable management, and biodiversity research in Asia's grassland ecosystems.

**Abbreviations:** China-VCS = China Vegetation Classification System; EDGG = Eurasian Dry Grassland Group; GIVD = Global Index of Vegetation-Plot Databases; IAVS = International Association for Vegetation Science; IVC = International Vegetation Classification; TWINSPAN = Two Way Indicator Species Analysis.

**Keywords**

Asia, Asian Regional Section, editorial vegetation classification, vegetation-plot database, grassland, International Association for Vegetation Science (IAVS), syntaxonomical scheme, vegetation ecology

## Introduction

Standardizing vegetation classification and adopting harmonized typologies are essential for understanding biodiversity patterns, ecosystem functions, and conservation strategies (De Cáceres and Wiser 2012; De Cáceres et al. 2015). Consistent typological frameworks enhance communication and data exchange across disciplines and regions (Dixon et al. 2014; Faber-Langendoen et al. 2014) while supporting biodiversity assessment, conservation prioritization, and policy development (Franklin et al. 2016; Janišová et al. 2016). Keith et al. (2022) emphasize that typologies provide an important basis for integrating ecological data across scales, facilitating ecosystem-specific management, restoration, and conservation policies (Dengler et al. 2008; Franklin et al. 2016; De Cáceres et al. 2018). Various plot-based (such as Braun-Blanquet approach, Synusial approach and EcoVeg approach) or not plot-based approaches (e.g. physiognomic-ecologic and dominant species approaches) can underpin any vegetation classification (De Cáceres et al. 2015). Asia, the world's largest continent, hosts over 60% of the global population and contributes nearly 40% of global carbon emissions (Zhu et al. 2021). This continent encompasses immense ecological, climatic, and cultural diversity (Zhu et al. 2021), containing 10 of the world's top 35 global biodiversity hotspots (Mittermeier et al. 2011). Grasslands, characterized by herbaceous vegetation mostly dominated by grasses or graminoids with minimal woody species and over 10% herb-layer cover (thresholds for tropical regions are tree cover below 40%) (Dixon et al. 2014; Dengler et al. 2020), are a vital component of Asia's diverse ecosystems. Based on their origin, Asian grasslands range from natural to semi-natural/anthropogenic grasslands (= secondary grasslands - which originate from human land use such as grazing, mowing, burning or abandoning arable fields) (Dengler et al. 2014, 2020; Wesche et al. 2016). Natural grasslands include steppes, arctic-alpine grasslands and tropical/subtropical savannas as zonal grasslands within the Palaearctic, Indo-Malay and Afrotropic biogeographic realms (Olson et al. 2001). Moreover, azonal/extrazonal grasslands driven by edaphic peculiarities rather than climate (Wesche et al. 2016; Dengler et al. 2020), such as saline grasslands, coastal dunes, riparian or wet grasslands, are widespread across Asia (Dudov 2018; Ushimaru et al. 2018). This ecological variability supports rich biodiversity, including numerous endemic species and glacial relicts (Dengler et al. 2020; Li et al. 2020a; Noroozi 2020), and provides critical ecosystem services such as carbon sequestration and soil stabilization (Ushimaru et al. 2018; Zhu et al. 2021). Acting as "green barriers" and "water towers," these grasslands are indispensable for Asia's ecological security (Li et al. 2020a). On the other hand, these important ecosystems face significant threats driven by both long term and short-term impacts imposed by overgrazing, agricultural expansion, rapid land-use changes, and climate change (Wesche et al. 2016; Török and Dengler 2018; Dengler et al. 2020). Habitat fragmentation, open-pit mining, eutrophication, afforestation, and infrastructure development exacerbate biodiversity losses (Ambarlı et al. 2018, 2020; Pfeiffer et al. 2018; Ushimaru et al. 2018). Socio-political shifts, including rural depopulation leading to grassland abandonment and restrictions on traditional pastoral practices, further intensify these pressures (Pfeiffer et al. 2018; Wagner et al. 2020).

Asia's grasslands, despite their ecological importance and all imposing threats and challenges, remain significantly underrepresented in global vegetation classification efforts. While notable advancements have been made in regions such as parts of North Asia and Russia (see below), Middle Asia (e.g., Nowak et al. 2024b, and references therein), and China (Guo et al. 2018), vast areas are still far from a reasonable vegetation classification. Grasslands in key regions of Asia, particularly South and Southeast Asia, are conspicuously absent from global typologies, highlighting substantial gaps in data and classification efforts (Dixon et al. 2014). For example, based on features provided by all plot-based vegetation typology papers published in the last five years in VCS, Asia, Africa and North America were least represented among the continents (Biurrun et al. 2025).

Recognizing these gaps, the Eurasian Dry Grassland Group (EDGG) supported by the International Association of Vegetation Science (IAVS) organized a virtual event, the Asian Grassland Conference (AGC) in 2022 (https://edgg.org/AGC; Venn 2022a, 2022b) where delegates identified the need for a collaborative approach to grassland ecology, vegetation and conservation. As the byproducts of the conference, a workshop was organized on the vegetation typologies in Asia and their crosswalks to/overlaps with phytosociological syntaxa, aiming to better understand vegetation typologies of Asia from a global point-of-view. Moreover, another kick-off workshop was organized on the foundation of an IAVS Regional Section in Asia, moderated by delegates from IAVS and EDGG. The members of the initiative committee for the Asian Regional Section, which was set up a few weeks before, were all in favour of a single Regional Section for the continent (Venn 2022b), and this committee organized all necessary steps regarding membership, establishment of steering committees and bylaws. This regional section was finally established in 2022 to promote vegetation ecology activities across the continent (Naqinezhad 2023) (https://www.iavs.org/general/custom.asp?page=workingroups_asiansection)

The Special Collection on “Grasslands of Asia” with a typological view was initiated as part of a broader effort to enhance understanding and collaboration among vegetation ecologists in Asia. It is a joint enterprise between the EDGG and the Asian Regional Section. While for the Asian Regional Section of IAVS, this is the first special feature in an international journal, EDGG has a long tradition in this respect, with more than 20 special features in various journals published so far on a wide variety of grassland-related topics. Some of the previous special features had been specifically devoted to grassland classification, namely in *Applied Vegetation Science* (Dengler et al. 2013), *Phytocoenologia* (Janišová et al. 2016) and *Vegetation Classification and Survey* (Nowak et al. 2022a), but usually dominated by contributions from the European part of the Palaearctic realm. Anyhow these special collections/features are considered crucial for the development of vegetation classification, especially in regions where it is still less developed (Biurrun et al. 2025).

The goal of this Special Collection was to provide a publication venue for any classification paper on Asia’s grasslands, improving data accessibility for both basic research and applied fields such as conservation, management, and policy development. The call for contributions encouraged studies that apply or test vegetation classifications, present data-driven insights into grassland ecosystems, or offer new tools in ecoinformatics (Biurrun et al. 2025).

This special collection explores the unique characteristics of Asia’s grasslands, providing insights into their typology and the progress of research in this field, particularly in Middle Asia and Southwest Asia. Notably, based on the response to our call for contributions, the review section of this editorial focuses on plot-based classification while encompassing various classification approaches, including

Braun-Blanquet, IVC, and non-formal methods (see Biurrun et al. 2025). In the following, we first present a concise overview of the grasslands of Asia and existing regional to national classification systems, then summarize the contributions to this special collection and finally wrap it up with conclusions and an outlook.

## Overview of the grasslands of Asia

Asia hosts a vast diversity of natural grasslands, spanning arctic-alpine, continental (steppes), and tropical (savannas) ecosystems, along with azonal types such as coastal and saline grasslands. This diversity is shaped by Asia's inclusion of all major biomes and three biogeographic realms (Olson et al. 2001; Loidi et al. 2022). The continent's complex geological and climatic history has significantly influenced the floristic composition and ecological functions of these ecosystems.

Currently, vegetation data from Asia are well-represented in several major global vegetation repositories, with some degree of overlap among them. The Global Index of Vegetation-Plot Databases (GIVD) (Dengler et al. 2011) includes 48 registered datasets from Asia, encompassing a total of 229,938 plots. Moreover, a total of 179,726 plots from various ecosystem types across 31 Asian countries have been contributed to the global vegetation-plot database sPlot (sPlot v.4.0) (Bruelheide et al. 2019; Sabatini et al. 2021) (Gabriella Damasceno, pers. comm.). For grassland ecosystems specifically, the GrassPlot database contains 6,782 independent plots and 29,520 nested subplots from Asian open habitats, with contributions from countries such as Armenia (119/479), Azerbaijan (408/2033), China (685/2479), India (561/753), Iran (2091/15661), Israel (319/2032), Japan (492/1380), Kazakhstan (364), Kyrgyzstan (7/91), Mongolia (492/786), Nepal (126/252), Russia (967/2459), Tajikistan (20/260), and Turkey (131/491) (Dengler et al. 2018; Biurrun et al. 2019). Moreover, three major datasets from Asian open and non-forest habitats—*Non-Forest Vegetation Database of Turkey (NFVDT)* (25,102 plots), *Grassland Communities of Anatolia* (3,021 plots), and the *Teberda-Caucasus Vegetation Database* (1,206 plots)—have been incorporated into the European Vegetation Archive (EVA) (Chytrý et al. 2016). It is important to note that there might be an overlap among GrassPlot/EVA and GrassPlot/sPlot. However, these overlaps are well documented in GrassPlot (Idoia Biurrun, pers. comm.)

Despite a relatively reasonable number of plot-based vegetation data in the above repositories, there are not enough classification systems across the continent. A synthesis of current data (Figure 1; Suppl. material 1) reveals a striking disparity in grassland classification across Asia. Only two countries have a comprehensive phytosociological system, and one has fully adopted the International Vegetation Classification (IVC)/EcoVeg approach, whereas 25 countries rely on partial classifications. Furthermore, 10 countries use only informal, local plot-based systems, 22 depend on coarse, no-plot based classifications, and 11 lack any grassland typology altogether, highlighting a critical gap in standardized vegetation documentation.

For this synthesis, we have divided Asia into six geographical regions, largely following the framework of Mapping Asia Plants (MAP; Ma 2017), similar to Dengler et al. (2020) for the Palaearctic part of Asia. Given that many comprehensive grassland studies are conducted at the national level, each country has been assigned to a single region, even though some countries exhibit significant biogeographic and climatic diversity.

**#Figure 1 approximately here#**

**North Asia**

The vegetation of North Asia (i.e., the Asian part of Russia) has been intensively studied in recent decades. However, most of these studies have been published in Russian journals, and only rarely in English. Notable contributions in this field include the journals *Vegetation of Russia* and *Flora and Vegetation of Asian Russia,* which have collectively published dozens of papers on the grasslands of Asian Russia. These journals primarily publish articles in Russian, accompanied by abstracts in English. A comprehensive review of publications before 2021 can be found in Nowak et al. (2022a) but the most recent phytosociological publications in these journals include the steppe vegetation of the Southern Urals (Korolyuk et al. 2022a; Zolotareva et al. 2024), Buryatia (Korolyuk et al. 2023), Zabaikalsky Krai (Anenkhonov and Naidanov 2024), and forest meadows of the Novosibirsk Oblast (Tishchenko and Zibzeev 2022). Additional studies have addressed steppes and meadows in Western Siberia (e.g. Tishchenko and Korolyuk 2020; Korolyuk et al. 2022b, 2024; Makunina 2022, 2023; Chupina and Korolyuk 2024) and the Altai Mountains (e.g., Basargin and Zibzeev 2018; Makunina et al. 2019, 2020). A significant development was the publication of a checklist of syntaxa in the Russian Arctic, detailing 241 associations from 20 classes (Matveyeva and Lavrinenko 2021). Since 2022, the journal *Flora and Vegetation of Asian Russia* has also been publishing syntaxonomic notes (e.g. Lysenko et al. 2022), focusing on the description, validation, and correction of syntaxa names and providing new data on their distribution.

Syntaxonomic studies on North Asian grasslands have also appeared in the English-language journal *Botanica Pacifica* over the last 13 years. These studies primarily focused on the Russian Arctic low growing vegetation (e.g. Telyatnikov et al. 2021, 2022, 2023, 2024; Lavrinenko et al. 2022; Teteryuk et al. 2022; Lapina and Lavrinenko 2023; Matveyeva and Lavrinenko 2023) and, to a lesser extent, on tall-forb meadows (Heim and Chepinoga 2019; Korznikov et al. 2024) and steppe vegetation (Golovanov et al. 2017).

It is noteworthy that the number of publications has increased markedly in recent years, primarily due to the initiation of the vegetation classification national programme (Plugatar et al. 2020). A classification (annotated prodromus) of the vegetation of Russia in three volumes has been announced, with the first two volumes scheduled for publication in 2025 (Olga Morozova, pers. comm.).

**Middle Asia**

Middle Asia, comprising Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, is a region of extraordinary ecological, geographical, and species diversity and plant endemism (Bragina et al. 2017; Li et al. 2020c; Khassanov et al. 2022). Spanning the core of the Eurasian landmass, it stretches from the Caspian Sea and Volga River in the west to northwest China in the east. The region's temperate continental arid climate, characterized by extreme temperature fluctuations and limited precipitation (e.g. Wagner et al. 2020), shapes extensive arid and semi-arid zones, including the Karakum and Kyzylkum deserts and among the tallest mountains worldwide. Large parts of the area are covered by various types of natural grasslands ranging from vast desert steppes and forest-steppes (e.g. Chibilyov 2002; Egamberdieva and Öztürk 2018) to alpine/nival grassland landscapes in Tian Shan and Pamir ranges (Khassanov et al. 2022; Nowak et al. 2024c). However, the origin of grasslands in the mountain regions of eastern and southern parts of Kazakhstan and Middle Asia is more complex and likely of both natural and anthropogenic origin (i.e. semi-natural, formed by a long practice of logging, burning and domestic livestock grazing) (Wagner et al. 2020). Middle Asia harbours a remarkable array of endemic flora adapted to harsh environmental conditions, including ancient plant lineages (Wagner et al. 2020; Kubentayev et al. 2024).

Grassland studies in this region have gained increasing attention, particularly concerning steppes and associated open habitats. However, plot-based vegetation classification remains underdeveloped apart from notable contributions by A. Nowak and colleagues (see for example Nowak et al. 2022b, 2023 and references therein). Physiognomic classifications have identified distinct steppe types in Kazakhstan, including forb-feathergrass meadow steppes, desert steppes interspersed with dwarf *Artemisia* and Chenopodiaceae shrubs and forest-steppe (Rachkovskaya and Bragina 2012; Bragina et al. 2017; Wagner et al. 2020). Korovin (1961, 1962) are among the pioneers publishing the first overview of vegetation in Middle Asia. A phytosociological study of steppe vegetation in eastern Kazakhstan by Cheng and Nakamura (2007) further enriches the understanding of this region's steppe ecosystems. In Kyrgyzstan and Tajikistan, mountain and alpine grasslands as well as chionophilous vegetation in the Tian Shan and Pamir-Alai ranges have been extensively classified, primarily through the efforts of

A. Nowak and his team (Swacha et al. 2023; Nowak et al. 2024b). Over nearly two decades, A. Nowak and colleagues compiled the Vegetation of Middle Asia database (Nowak et al. 2017), encompassing over 5,800 relevés from Tajikistan, Kyrgyzstan, and Uzbekistan, along with additional records from neighbouring countries such as Iran, Russia, Kazakhstan, Afghanistan, and China. Their synthesis includes 45 classes, 47 orders, 83 alliances, 297 associations, and 237 rankless units, marking a significant step toward a comprehensive classification for Middle Asia (Nowak et al. 2025). In contrast, Turkmenistan and Uzbekistan remain underexplored in terms of grassland typology. However, some studies, such as those on the ephemeroid vegetation of the Kulan Plateau in the Badhyz Reserve in Turkmenistan (Polyakova et al. 2023), have contributed important data on specific plant communities.

**Central and East Asia**

This area includes East Asia encompassing the Korean Peninsula (North and South Korea) and Japan and Central Asia encompassing Mongolia, China (and Taiwan) (Wesche et al. 2016). The whole area is considered as Northeast Asia in the floristic point of view adopted in MAP (Ma 2017). Grasslands dominate much of its open landscapes, particularly in Mongolia and China (Wesche et al. 2016; Brown 2020; Li et al. 2020b). Both latter countries host the world's largest continuous grasslands with the majority of which considered natural (Pfeiffer et al. 2018) and considered relatively intact, representing what has been called the world's finest grasslands (Batsaikhan et al. 2014).

The main physiognomic vegetation formations of natural grasslands in China and Mongolia have been recently classified by Pfeiffer et al. (2018) including groups of forest-steppe, grass steppe, desert steppe, alpine steppe and alpine meadow. Early vegetation studies, influenced by different schools of vegetation science, were predominantly published in Chinese and adopted varied methodologies (Hou 1960; Wang 1988; Zhang 1988; Song 2011). This limited their visibility and integration into global vegetation research frameworks (see also Pfeiffer et al. 2018). However, in recent decades, there has been a notable shift toward more standardized approaches and greater alignment with international systems, such as the International Vegetation Classification (IVC) (Guo et al. 2018; Fang et al. 2020). The development of China Vegetation Classification System (China-VCS) reflects the unique evolution of vegetation science in China. China-VCS is a hierarchical system that integrates physiognomy, floristic composition, ecological attributes, and dynamic processes to classify its diverse vegetation (Guo et al. 2014; Fang et al. 2020). This system distinguishes cultural vegetation from natural and semi-natural vegetation, utilizing eight hierarchical levels: vegetation-type group, vegetation-type, vegetation-subtype, formation group, formation, sub-formation, association group, and association (Guo et al. 2018; Zhu et al. 2019). Modern studies increasingly adopt frameworks that are accessible to the global community, exemplified by comprehensive classifications like those applied in the Hulunbeier steppe (Zhu et al. 2019) and *Stipa*-dominated grasslands across China (Liu et al. 2022), both with IVC approach. In the Hulunbeier steppe, one of the best conserved grasslands in northern China (Pan et al. 1992), Zhu et al. (2019) demonstrated the application of this system, incorporating elements of classical phytosociology, such as associations and alliances, while aligning them with the China-VCS framework. Although association and alliance levels are included, formal nomenclature is not yet standardized, and classifications are presented descriptively (Zhu et al. 2019; Yang et al. 2022). For instance, general vegetation types follow China-VCS nomenclature, while association descriptions incorporate elements of phytosociological practices such as type relevés (Fang et al. 2020; Guo et al. 2020; Wang et al. 2020). By contrast classical Braun-Blanquetian classification studies were rarely conducted in China, namely by Nakamura et al. (1988: Xilian river basin in Inner Mongolia), Miehe et al. (2011: alpine steppes of the Tibetan Plateau), Cheng et al. (2013: steppes in the Hulunbeier region), and Kim et al. (2019: alpine vegetation of NE China), and all of which have been conducted by foreigners.

About 80% of the total area of the Mongolian territory is classified as grasslands and arid rangelands (Pfeiffer et al. 2020), comprising the natural zonal groups of forest steppes (sensu Dengler et al. 2014, 2020), typical steppes, and desert steppes of the Palaearctic steppe biome (Hilbig 1995; Wesche et al. 2016; Pfeiffer et al. 2020). Diversity in flora and vegetation of grasslands are enriched by the fact that the country is biogeographically located at the intersection between three different subkingdoms (i.e., the Boreal, Tethyan, and East Asian subkingdoms) of the Holarctic realm (Pfeiffer et al. 2020).

The grasslands and steppe vegetation of Mongolia has been systematically studied using plot-based approaches by many authors (Hilbig 1990, 1995, 2000, 2003; Dulamsuren et al. 2005; Von Wehrden et al. 2006; Cheng et al. 2008; Zemmrich et al. 2010; Suzuki et al. 2021, 2023) offering detailed syntaxonomic classification.

In Japan, the climatic community corresponds to various types of forests (Ushimaru et al. 2018). Grasslands are divided based on their origin into three groups of “natural” (maintained or temporally established by natural disturbances and specific soil conditions), “semi-natural” (maintained by continuous anthropogenic managements) and “secondary” (established temporally or maintained continuously after land-use changes and grazing animals) (Ushimaru et al. 2020). Natural grasslands include very limited areas, such as alpine meadows, riparian areas and coasts which are considered equivalent to the azonal and extrazonal grassland types ( *sensu* Dengler et al. 2014, 2020). However, the majority of grasslands in Japan correspond to various types of semi-natural (pastures and meadows) and secondary grasslands (Ushimaru et al. 2020), both types included among secondary grasslands by Dengler et al. (2014, 2020).

An overview of various grassland types and their dominant species is provided on a dominant-ecologic-physiognomic approach by Ushimaru et al. (2020). From a phytosociological point of view, the country has a rich and long-standing tradition in phytosociological research (Nowak et al. 2022a), with early foundational works significantly shaping vegetation science in the region. Early studies, such as those by Yamanaka (1950, 1960), Taniguchi (1958), Itow (1962, 1974), Suganuma (1966, 1967), Lieth et al. (1973), and Ohba (1974), focused on classifying semi-natural and natural grasslands. Numata (1969 and many references therein) further advanced these efforts, examining gradients of grassland succession and providing insights into ecological dynamics and vegetation trends. The late 20th century marked a pivotal period for vegetation science in Japan, with major contributions like the "Japan Vegetation Record" (Miyawaki 1980-1989; Fujiwara 1996), providing detailed classifications. Moreover Miyawaki and Suzuki (1980) tried to foster vegetation science and mapping using phytosociological methods in Japan and Yamato et al. (2004) has syntaxonomically assessed grasslands of Ryukyu Island of Japan. Much of Japan's early phytosociological research was published in Japanese (Nowak et al. 2022a). More recently, Shimoda et al. (2020) made a significant contribution by compiling the largest publicly available grassland vegetation dataset in Japan. This database, encompassing 28 grassland sites from Hokkaido to Kyushu, provides critical insights into semi-natural and artificial grasslands (see Ushimaru et al. 2018), supporting conservation and management efforts. Unfortunately, there is almost no new research on the typological diversity of Japan's grasslands.

The Korean Peninsula, in contrast, has fewer classification studies but still keeping a tradition on vegetation classification, with limited contributions focused on open habitats and grasslands (Kolbek and Jarolímek 2013). Early works like those of Blažková (1993) or Sádlo and Kolbek (1997) and more recent studies on montane grasslands (Kim et al. 2024) highlight the need for broader systematic efforts. There are also some papers in the Korean language published on classical phytosociology of this peninsula (e.g., Kim and Jang 1989; Shin et al. 2009, 2015; Lee and Ahn 2012; Kim et al. 2017).

Taiwan has limited literature on grassland typology, with vegetation monitoring studies like Lee (2005) providing valuable, though fragmented, insights.

**West Asia**

West Asia (also called Southwest Asia), covering the Middle East, the Arabian Peninsula, and the Caucasus, is a region of remarkable ecological, cultural, and historical significance and renowned as the cradle of early civilizations and a centre for crop domestication (Zohary et al. 2012; Ghazanfar and McDaniel 2016). The region's climate, ranging from cool temperate and Mediterranean to xeric and monsoonal zones (Loutfy Boulos and Miller 1994), fosters a rich vegetation mosaic within the transition zone of the Holarctic and Palaeotropical floristic kingdoms (Takhtajan 1986) embracing four phytogegraphical regions, "Euro-Siberian" "Irano-Turanian", "Mediterranean" and "Saharo-Sindian" (Zohary 1973; Léonard 1981-1989).

Global biodiversity hotspots, such as the Irano-Anatolian and Caucasus regions, comprising a large proportion of grasslands and steppes, highlight its high levels of plant endemism (Noroozi 2020). The current vegetation classification efforts in this region, while valuable, remain fragmented and require more comprehensive and standardized methodologies (Nowak et al. 2022a).

The region hosts a diverse range of grasslands, ranging from natural to semi-natural, primarily shaped by elevation. These grasslands include plain steppes, such as desert steppe and treeless steppe grasslands, as well as montane and alpine steppes. Additionally, steppe woodlands and forest-steppes contribute to the region's ecological diversity. Alongside these zonal grasslands, azonal types also exist, including saline vegetation in vast lowland depressions and mesophilic mountain grasslands, both of which are considered either natural or semi-natural (Ambarlı et al. 2018; Ramzi et al. 2024).

Despite being classified as natural vegetation in much of the region, these grasslands and their vegetation structure have been profoundly shaped by long-term anthropogenic pressures over millennia. Grazing and human activity have driven significant ecological changes, leading to two key processes: so-called "ruderalization" (*sensu* Zohary 1973), characterized by the expansion of disturbance-adapted ruderal species, and "tragacanthization" (*sensu* Zohary 1973), also referred to as "antipastoralism", which involves the proliferation of unpalatable, thorny-cushion grazing-resistant vegetation. This latter process is particularly evident in high mountain zones across the Middle East and Southwest Asia (Zohary 1973; Breckle et al. 2013). As a result, thorny cushion vegetation, composed of endemic-rich genera such as *Astracantha, Astragalus*, *Acantholimon*, *Acanthophyllum*, *Onobrychis*, *Gypsophylla*, *Cousinia*, and *Arenaria*, and unpalatable dwarf-shrub communities of *Artemisia* dominate these landscapes (Zohary 1973; Ariapour et al. 2017; Ambarlı et al. 2018). A particularly striking ecological transformation occurred in the fertile-crescent of Irano-Anatolian region, where human activity since the Neolithic period has progressively altered prehistoric grasslands. Drawing on anthracological, pollen and modern vegetation data, it was hypothesized that early landscape management practices led to the gradual replacement of species-rich, post-Pleistocene semi-arid savanna form grasslands with low-diversity, even-aged *Quercus*-dominated parklands (*sensu* Zohary 1973) or steppe-forest (Erdős et al. 2018) by the early Holocene (Asouti and Kabukcu 2014).

The foundational geobotanical studies and vegetation mapping in the region were laid by Zohary (1973), who provided a seminal classification of Middle Eastern vegetation including its grasslands and steppes. Pioneering efforts in vegetation description, classification and mapping using physiognomic-ecological approach were made by Freitag (1971) specifically for Afghanistan, Mobayen and Tregubov (1970) and Frey and Probst (1986) for Iran and Frey and Kürschner (1989) for whole Middle East and laid the foundation for subsequent research.

Turkey and Iran, in particular, have made significant contributions to the phytosociological understanding of West Asia (Ambarlı et al. 2018, 2020; Nowak et al. 2022a). Early works such as those by Quézel (1973), Akman et al. (1984, 1996), and Kürschner (1986) classified diverse vegetation types, including steppes, and alpine meadows. These studies inspired further database works conducted by Güler (2021) in Turkey. Similarly, Ramzi et al. (2024) provided a comprehensive synthesis of historical and ongoing vegetation classification efforts across various ecosystems, including grasslands and steppes, in Iran. For open habitats, Naqinezhad et al. (2021) provided a syntaxonomy of relict mountain fens and wet meadows of Iran and the Irano-Turanian region (see also Kamrani et al. 2011; Jalili et al. 2014). Additionally, Mahdavi et al. (2017) and Tirgan et al. (2022) dealt with the vegetation of Iran's sand dunes, while Akhani (2004) and Akhani and Mucina (2015) developed a syntaxonomical framework for the country's halophytic vegetation. Meanwhile, Noroozi (2020 and references therein) have surveyed the vegetation of mountains, alpine steppes and grasslands across SouthwestAsia, with a particular focus on Iran and Middle Asia (see also Naqinezhad and Esmailpoor 2017). In contrast, other West Asian countries—such as those in the Arabian Peninsula, the Caucasus, and the Levant—have seen more limited progress. Grasslands of Caucasus countries have been fragmentarily studied particularly using plot-based classification approaches (e.g. Pyšek and Šrůtek 1989; Peper et al. 2010; Etzold et al. 2016; Jabbarov et al. 2020; Nakhutsrishvili et al. 2022). Early advances in the physiognomic classification of grasslands, coastal sand dunes, sabkha ecosystems, halophytic vegetation, and related open habitat communities were provided by Schulz and Whitney (1986), Deil and al Gifri (1998), and Brown (2006) in the Arabian Peninsula. Also several plot-based local studies have emerged in this region, including works by Kürschner et al. (2006) and De Sanctis et al. (2013) in Socotra, as well as studies in Saudi Arabia by El-Demerdash (1996), Shaltout et al. (1997), and Kürschner and Neef (2011), in Qatar by Babikir (1984), in Bahrein by Abbas et al. (1991), in Emirate by Deil and Müller-Hohenstein (1996), and Kuwait by Abbadi and El-Sheikh (2002).

Limited studies from other parts of the region further highlight significant knowledge gaps. For example, research in the Palestine and Israel region has been conducted by Danin (1988), Ighbareyeh et al. (2022), and El-Sheikh et al. (2003) and, while Stephan et al. (2019) and Zein et al.

(2024) have contributed to vegetation studies in Lebanon. In Iraq, earlier work by Abul-Fatih (1975) focused on the vegetation of saline depressions.

**South Asia**

South Asia, comprising Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka, is a geographically and ecologically diverse region. This section features rugged mountain ranges such as the Hindu Kush, Karakoram, and Himalayas as well as the expansive Indo-Gangetic Plain, and diverse ecosystems, including tropical rainforests, montane grasslands, and coastal vegetation (Xiao et al. 2023). Despite their ecological richness, grasslands in South Asia remain underexplored, with much of the research relying on descriptive physiognomic surveys rather than plot-based classification efforts.

India has historically been a focal point for grassland studies. Early works by Bharucha and colleagues in the mid-20th century laid the groundwork for understanding forest and grassland communities (Bharucha and Dave 1952; Bharucha and Shankarnarayan 1958; Bharucha 1975). These studies identified seven major natural grassland types, including coastal grasslands, riverine alluvial grasslands, montane grasslands, alpine grasslands, sub-Himalayan tall grasslands, tropical savannas, and wet grasslands (Dabadghao and Shankarnarayan 1973; Chandran 2015; Ratnam et al. 2016). Moreover, the country is characterised by a diverse range of unique “ethnic grasslands”, each with a distinct floristic composition and high ecological value (Malaviya et al. 2017).Despite the vast extent of grasslands, there is no clear approach to their classification and typology. In India, no formal framework exists for grassland classification, and most studies have focused on species diversity rather than typological classification. Some plot-based studies, such as those by Galav et al. (2005), Reddy et al. (2011), Yadav et al. (2020), and Bhutia et al. (2024), refer to their work as phytosociological research. However, these studies primarily use phytosociology as a tool to assess species diversity and ecological attributes rather than as a means of systematically classifying grassland ecosystems. Notable exceptions include classical phytosociological works in Ladakh by Hartmann (1987, 1990, 1999), Klimes (2003), and Dvorský et al. (2011), which provided valuable insights into high-altitude grassland plant communities and their elevational gradients.

In Nepal, the Himalayan biodiversity hotspot has been the focus of several phytosociological and ecological surveys. Bürzle et al. (2017) studied treeline ecotone vegetation in the Rolwaling Himal. Vetaas and Grytnes (2002) conducted extensive studies on elevational patterns of plant diversity along the Himalayan mountains, further complemented by the work of Bhattarai and Vetaas (2003). Sri Lanka’s montane grasslands have been fragmentarily studied by some foundational works by Pemadasa and Mueller-Dombois (1979, 1981) and Pemadasa and Amarasinghe (1982). In Pakistan, significant efforts have been made to classify steppe and grassland communities and their underlying ecological variables using informal plot-based classifications approaches (Tareen and Qadir 1991; Iqbal et al. 2021; Mumshad et al. 2021; Zeb et al. 2021). Same as the situation in India, community traits such as plant species composition, distribution patterns, density, cover and frequency were considered as “phytosociological characteristics” in these publications rather being treated as a means of systematically classifying grassland ecosystems. Nevertheless, Peer et al. (2007) provided a formal classification of steppe vegetation in northern Pakistan.

**Southeast Asia**

Southeast Asia, comprising Brunei, Cambodia, East Timor (Timor-Leste), Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam, is predominantly characterized by tropical forests, with grasslands occurring in more localized areas. These grasslands primarily include tropical savannas, which represent the region’s natural lowland grasslands, as well as floodplain grasslands (e.g., Chea et al. 2024) and secondary grasslands dominated by *Imperata cylindrica* and its various vegetation types, often resulting from deforestation or agricultural activities (Seavoy 1975; Garrity et al. 1996; Dove 2004). It is expected that more secondary grasslands will be developed due to climate change and fire disturbances through the process of so-called "savannization" of tropical forests (Wang et al. 2023). *Imperata cylindrica*, a native species, is estimated to cover approximately 35 million hectares across Asia, with its primary distribution in tropical regions (Moog 1990; Garrity et al. 1996). Some of the earliest plot-based studies on these grasslands were conducted in South Sumatra, Indonesia, where researchers classified them ecologically and described their successional development from tropical rainforests (Tanimoto 1961).

The only formal phytosociological classification in the region has been conducted in Thailand, where studies have examined plant community structure and the phytosociology of coastal dunes (Suzuki et al. 2005; Laongpol et al. 2009).

## Content of the special collection

Despite the call being open to all classification approaches—including IVC, non-formal methods, remote sensing (RS)-based classifications, formations, and biomes—from all parts of Asia, the *VCS* special collection comprises seven articles from just four countries in West and Middle Asia (Figure 2). Four regions of Asia are entirely unrepresented, and many countries within the two included regions are also missing. The methodological approaches in the collected studies range from detailed phytosociological analyses based on vegetation plots to broader investigations of grassland ecology and floristics. The following sections introduce these studies in detail.

**West Asia**

**Vynokurov et al. (2024**) (Figure 2a) delivered the first syntaxonomic, plot-based classification of Armenia's dry grasslands and thorn-cushion communities, proposing a potential new vegetation class, *Ziziphora tenuior-Stipa arabica* grasslands, distinct from the Euro-Siberian *Festuco-Brometea* and Anatolian *Astragalo-Brometea*. Based on 111 vegetation plots sampled during the 13th EDGG Field Workshop and supplemented with 487 plots from surrounding countries, the study utilized the modified TWINSPAN (Two Way Indicator Species Analysis) to classify the plots from Armenia in 12 vegetation clusters. These clusters were assigned to five broad-scale groups, with half of the Armenian plots fitting into the new class. The authors described three new orders, four alliances, and six associations, showcasing significant differences in species composition, site conditions, and structural parameters between the units. With a mean vascular plant richness of 46.8 species per 10-$m^2$ plot, well above the Palaearctic dry grassland average (33.7 according to the GrassPlot Diversity Explorer, https://edgg.org/databases/GrasslandDiversityExplorer; see Biurrun et al. 2021), this study highlighted the unique biodiversity of Armenian grasslands and supported their conservation while advancing the understanding of Caucasian vegetation.

**Talebi et al. (2024)** (Figure 2b) presented a pioneering syntaxonomic classification of the diverse vegetation along the southern slopes of Mt. Damavand, the highest summit in the Middle East, reaching 5,610 m a.s.l. Covering a 3,000-m elevational gradient, this study comprehensively analyzed rocky habitats, screes, snow-beds, and grasslands, identifying four distinct vegetation classes: rocky habitats (*Tanacetalia kotschyi*, class unknown), screes (*Didymophyso aucheri-Dracocephaletea aucheri*), snow-beds (*Salicetea herbaceae*), and grasslands (*Astragalo-Brometea*). The researchers distinguished six orders, nine alliances, and 18 association-level communities, many of which are newly described, including two alliances (*Artemision aucheri* and *Cousinion petrocauli*) and seven associations. The results revealed significant floristic distinctions between vegetation groups, driven primarily by elevation, which influences species composition and ecological specialization. Mt. Damavand's high endemism and geographic isolation led to striking vegetation differences regarding nearby regions like the Caucasus, Anatolia, and Middle Asia. This work not only advanced the classification of Iranian alpine and subalpine ecosystems but also included previously understudied lower-elevation vegetation, such as semi-natural mown tall herb-rich grasslands, which were associated with the new alliance *Cousinion petrocauli*. By situating Mt. Damavand's vegetation within the broader phytosociological framework, the study underscored the ecological significance of this region while highlighting the need for further exploration of the Alborz Mountains and other

Iranian ranges. This comprehensive vegetation analysis is expected to serve as a critical resource for understanding and conserving the unique biodiversity of Iran's mountainous landscapes.

**Noroozi et al. (2024)** (Figure 2c) provided an in-depth investigation of the Dena Mountains, the highest peak in the Zagros range (4,409 m a.s.l.), renowned as the second richest centre of plant endemism in the region. The study examined the floristic connections of Dena to adjacent mountain ranges, identified species reaching the subnival zone, and characterized its unique plant communities. A total of 242 taxa endemic to the Iranian Plateau were found in Dena, with 22 being strictly endemic to the area. The mountains exhibited the strongest floristic affinity with the Yazd-Kerman massif, sharing 84 taxa, compared to fewer shared taxa with the Alborz (51), Azerbaijan Plateau (37), and Kopet Dagh-Khorassan (15). In the subnival zone, 38 taxa occurred, most of which (68%) were endemic to the Iranian Plateau. The authors described two new associations from scree habitats: *Aethionemetum umbellati* and *Zerdanetum anchonioidei*, which form part of the newly established alliance *Galion pseudokurdici*, nested within the class *Didymophyso aucheri-Dracocephaletea aucheri*. This study underscored the vulnerability of high-altitude ecosystems in the Dena Mountains to climate change, particularly the risk posed to alpine and subnival habitats. While the region lies within a protected area, the authors highlighted that protection alone cannot mitigate the impacts of global warming, which is likely to shrink these habitats. They called for intensified conservation measures targeting range-restricted and elevation-dependent species to safeguard this biodiversity hotspot.

In the nearby mountains of Fereydunshahr, Iran (Figure 2d), **Yaselyani et al. (2024)** focused on the plant diversity of the subalpine and alpine zones, describing their life-form and chorological spectra, as well as their affinity to the vegetation types described in the area, i.e., montane steppe shrublands, subalpine tall-umbelliferous vegetation, subalpine and alpine thorn-cushion grasslands, chasmophytic vegetation, and wetlands. This study highlighted the floristic uniqueness of the Central Zagros, with almost 20% of the 308 listed species being endemic to Iran, and 7% to Zagros Mountain range. The genus *Astragalus* stands out, with 24 species, 14 of them endemic to Iran and six to Zagros. Most of these endemic species grew in the subalpine and alpine thorn-cushion grasslands, although the vegetation type with highest proportion of endemics (56%) was the subalpine tall-umbelliferous vegetation. The authors emphasized the need of more comprehensive studies on the flora and specially on vegetation of the mountains of Fereydunshahr, which are fundamental for the development of protection and conservation strategies.

**Middle Asia**

**Nowak et al. (2024a)**(Figure 2e-f) provided a comprehensive analysis of pistachio woodlands, proposing a new vegetation class, *Pistacietea verae*, to highlight their ecological and phytogeographical distinctiveness across Tajikistan and Iran. These open, deciduous woodlands, with a high proportion of grasses and forbs, occurred in the colline-montane belts of the Irano-Turanian region, including the Pamir-Alai, Zagros, Kopet-Dagh, and Alborz mountains. These woodlands are considered part of the forest steppe category, which is widely distributed across the Irano-Turanian region (Bragina et al. 2017; Ambarlı et al. 2018; Erdős et al. 2018). By analyzing two datasets—one specific to pistachio groves (110 relevés) and another comparative dataset (1,276 relevés) of floristically related communities—the study utilized the modified TWINSPAN algorithm to classify plots into clusters and applied NMDS ordination to explore group relationships. The findings revealed the unique floristic composition of pistachio woodlands, characterized by high levels of endemism, with species such as *Ajuga turkestanica, Astragalus quisqualis,* and *Tulipa subquinquefolia*. With a sparse *Pistacia*-dominated canopy that allows significant light penetration, the understory supports a diverse range of herbaceous plants and shrubs, enhancing overall biodiversity. Two associations, *Pistacietum verae* and *Pistacietum khinjuk*, defined the new class, which showed marked differentiation from neighbouring vegetation types such as *Quercetea ilicis* and *Crataegetalia ponticae*. This study underscored the ecological significance of *Pistacia* open woodlands as an under-researched zonal vegetation type and advocated for targeted conservation strategies to preserve these fragile ecosystems, which extend from Iran to Tajikistan and potentially into Afghanistan, Uzbekistan, and Pakistan.

**Świerszcz et al. (2022)** (Figure 2g) explored the distribution of graminoids across five open vegetation types in Tajikistan and Kyrgyzstan, revealing how climatic factors and grazing pressures shaped vegetation patterns in these ecosystems. By analyzing 1,525 vegetation plots from the *Vegetation of Middle Asia* database (Nowak et al. 2017), the study highlighted the crucial ecological role of graminoids, particularly in steppes, pseudosteppes, and mires, where their relative cover was highest. Applying polynomial functions and commonality analysis, the research identified key drivers of diversity, including mean annual temperature, precipitation, aridity, and livestock density. Notably, pseudosteppes exhibited a strong correlation between graminoid cover and grazing intensity, confirming their secondary origin due to anthropogenic pressures. In contrast, for steppes and salt marshes, temperature and aridity were the primary determinants of graminoid distribution, with salt marshes being particularly vulnerable to rising temperatures under climate change. Meanwhile, mires and tall-forb communities showed weak or negligible responses to the studied variables. This study underscored the multifaceted factors influencing graminoid contributions to Middle Asia's open vegetation types and warned of potential declines in graminoid cover in salt marshes, steppes, and pseudosteppes due to ongoing climate change and overgrazing. By providing critical insights into graminoid ecology, it laid the groundwork for sustainable management strategies to preserve these ecosystems and their essential functions in the face of environmental change.

**Świerszcz et al. (2023)** (Figure 2h) presented a detailed classification of subalpine forb steppes in the Pamir-Alai Mountains, proposing a new vegetation class to reflect the ecological and floristic uniqueness of these dicot-rich grasslands in the Irano-Turanian region. Drawing from 149 relevés sampled in 2014 and 2021, the study utilized a modified TWINSPAN algorithm to classify clusters and Detrended Correspondence Analysis (DCA) to explore compositional differences between alpine and subalpine grasslands.

The research identified 12 vegetation clusters, including nine new associations and three communities, each characterized by distinct species compositions influenced by environmental variables such as diurnal temperature ranges, annual precipitation, precipitation seasonality, and minimum winter temperatures. Among the newly proposed vegetation types were subalpine forb steppes with *Eremogone griffithii* and *Nepeta podostachys*, as well as mesic alpine grasslands dominated by *Festuca alaica* and *Festuca kryloviana*. These forb steppes were particularly notable for replacing juniper open woods in the upper montane and subalpine belts, signifying a major ecological shift. The study contributed to a broader understanding of upper montane and subalpine grasslands in Middle Asia, providing a consistent hierarchical classification framework while emphasizing the need for further research to refine the syntaxonomic positions of certain communities. The findings underscored the role of forb steppes as a distinct and ecologically significant vegetation type within the Pamir-Alai region.

**#Figure 2 approximately here#**

## Conclusions and future perspectives

Plot-based vegetation classification is widely recognized as fundamental for understanding and managing ecosystems globally (Dixon et al. 2014; De Cáceres et al. 2018; Keith et al. 2022). Such classifications enhance insights into vegetation dynamics and provide standardized frameworks essential for cross-regional ecological comparisons and targeted conservation strategies (Janišová et al. 2016; Nowak et al. 2022a). Our synthesis of current data (Figure 1), however, reveals significant gaps in the application of plot-based vegetation classification across Asia. Only two countries have established comprehensive phytosociological classification systems, and only one country has fully adopted the IVC/EcoVeg approach, whereas 25 countries rely on partial classifications. Ten countries employ solely informal, local plot-based methods, 22 use coarse, non-plot-based systems covering entire nations, and 11 have no established grassland typology at all. While notable progress has been made in regions such as Russia, Middle Asia, West Asia, and parts of China (Guo et al. 2018; Güler 2021; Ramzi et al. 2024; Nowak et al. 2025), large geographic areas remain underrepresented. For instance, this special collection does not include contributions from Central Asia, South Asia, North Asia, Southeast Asia, or East Asia, despite these regions encompassing some of the world's most extensive and ecologically significant grasslands (Dixon et al. 2014; Wesche et al. 2016). Notably, phytosociological research in North Asia (Russia) has advanced significantly, as demonstrated by the ongoing national vegetation classification program (Plugatar et al. 2020) and the forthcoming three-volume prodromus documenting at least 250 grassland associations (Olga Morozova, pers. comm.).

The inconsistent methodological approaches and substantial documentation gaps across Asia stem largely from the continent's immense geographic, ecological, and cultural diversity (Nowak et al. 2022a). Socio-political and economic barriers—including uneven research capacities, economic disparities, geopolitical tensions, language barriers, and restrictive visa policies—further exacerbate these challenges (Ambarlı et al. 2018; Nowak et al. 2022a). Additionally, studies in regions such as South and Southeast Asia often remain fragmented and dominated by agricultural or forestry perspectives rather than typological classification.

A practical approach to addressing these challenges involves strengthening regional vegetation databases and classification frameworks. Successful regional prototypes, such as the Middle Asian database (Nowak et al. 2017) and the Vegetation Database of Iran (IranVeg; Ramzi et al. 2024), demonstrate how systematic data collection can serve as a foundation for developing a comprehensive, continent-wide resource. Furthermore, special initiatives, such as this *Grasslands of Asia* Special Collection, represent essential steps toward promoting local and regional data collection efforts, ultimately contributing to a unified framework for classifying and conserving Asian grasslands. Future research should specifically target regions where substantial gaps remain, including South and Southeast Asia, the alpine and high-mountain grasslands of the Himalayas, and the expansive desert steppes of the Middle East, all of which urgently require increased attention and focused local studies.

Moving forward, there is a clear need to develop a unified, continent-wide vegetation classification framework that addresses existing methodological and data gaps. Initiatives such as the Mapping

Asia Plants (MAP) project (Ma 2017; Xue et al. 2020; Xu et al. 2020; Xiao et al. 2023) offer promising models for integrating local, regional, and national datasets. Experiences from other continents—including Europe's European Vegetation Archive (EVA; Chytrý et al. 2016), North America's VegBank (Peet et al. 2012), and Australia's TERN-AEKOS archive (Chabbi and Loescher 2017)—demonstrate the substantial benefits of collaborative databases in advancing large-scale ecological research and supporting informed conservation planning. In contrast, Asia, much like Africa (Guuroh et al. 2024) and Latin America (Peyre et al. 2024), lags behind due to methodological fragmentation, limited data accessibility, and geopolitical barriers. Establishing a similar collaborative framework specifically for Asia's vegetation, particularly its diverse grasslands, would significantly enhance cross-regional and international cooperation, address critical data deficiencies, and advance biodiversity research across the continent. Fortunately, the availability of Asian vegetation data in global repositories—such as the Global Index of Vegetation-Plot Databases (GIVD; Dengler et al. 2011), sPlot (Bruelheide et al. 2019; Sabatini et al. 2021), GrassPlot (Dengler et al. 2018; Biurrun et al. 2019; Boch et al. 2021), and EVA (Chytrý et al. 2016)—already provides a solid foundation upon which these efforts can build.

The Asian Regional Section of the International Association for Vegetation Science (IAVS) is uniquely positioned to facilitate this critical transition. With 117 members from 29 countries, including 17 Asian nations, it serves as an essential platform for scientific exchange, capacity building, and collaboration, especially benefiting early-career researchers. Through organizing workshops, field studies, and conferences, the Asian Regional Section actively promotes knowledge sharing, standardization of methodologies, and the establishment of partnerships to strengthen regional collaboration. Expanding membership and fostering stronger connections with underrepresented countries will be pivotal in addressing Asia's vegetation ecology challenges effectively.

## Author contributions

ANa planned and drafted this Editorial, while all other authors contributed, revised and approved it.


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## Supplementary material

**Supplementary material 1:** Distribution of 48 Asian countries according to the methodological approach for grassland classification.

## Figures

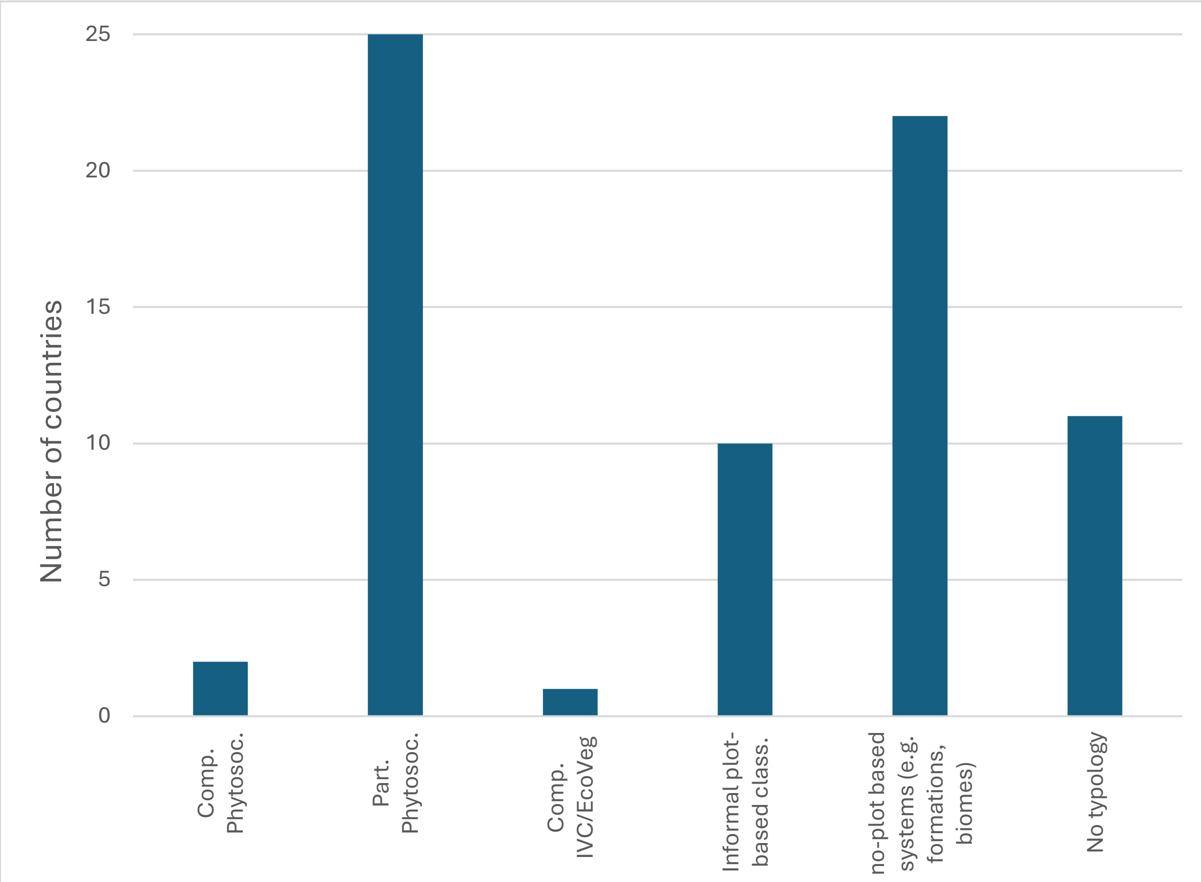


Figure 1. Distribution of 48 Asian countries according to the methodological approach for grassland classification (Comp. Phytosoc. = Comprehensive phytosociological classification system available in the country; Part. Phytosoc. = Partial phytosociological classification system available in the country; Comp. IVC/EcoVeg. = Comprehensive IVC/EcoVeg system available in the country; Informal plot-based class. = Some informal local plot-based classification available in the country; no-plot based systems (e.g. formations, biomes) = Coarse, no-plot based systems, but for the entire country (e.g. formations, biomes); No typology = No grassland typology found in the country). Country level information is provided in Suppl. material 1.

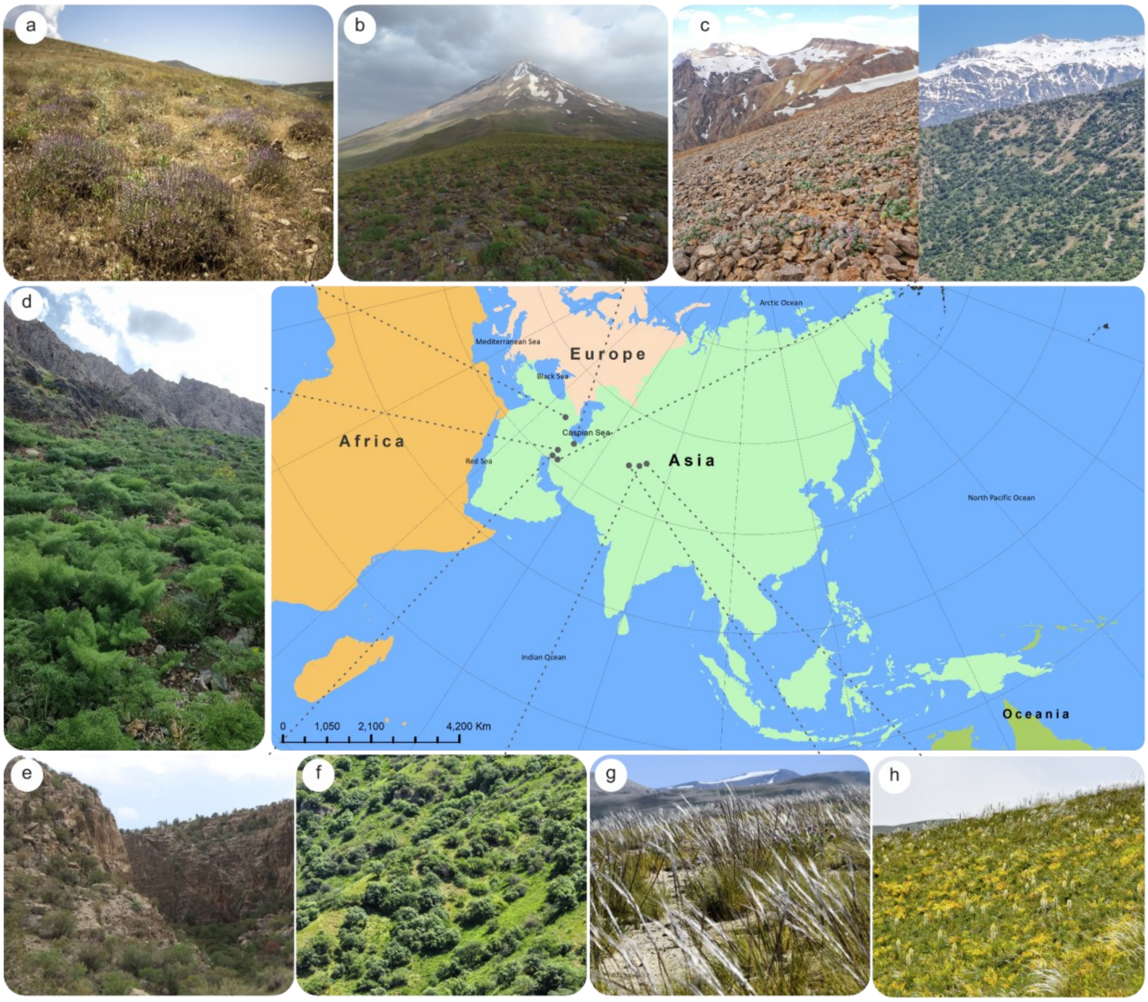


**Figure 2.** Examples of Asian grassland types. a) *Acantholimono caryophyllacei-Stipetum holosericeae*, Armenia; b) Alpine vegetation in Damavand Mts with *Acantholimetum demawendici* as the main vegetation at altitude 3,700 m a.s.l.; c) *Quercus brantii* forest steppe (2,000–2,600 m a.s.l.) on the right-hand side and *Aethionemetum umbellati* scree vegetation (4,200 m a.s.l.) on the left-hand side, both from Dena Mts; d) Fereydunshahr: tall umbelliferous vegetation type (2,800 m a.s.l.); e) *Pistacietum khinjuk* near Ramhormoz, Iran; f) *Pistacion verae* near Nurek, Tajikistan (1,450 m a.s.l.); g) cryophilous steppe near Alichur, Eastern Pamir, Tajikistan (3,900 m a.s.l.), h) forb steppe of *Eremogono griffithii-Nepetetea* near Koshtegirmen, Tajikistan (3,300 m a.s.l.).

Photos by: D. Vynokurov (a), A. Talebi (b), J. Noroozi (c–d), A. Naqinezhad (e), A. Nowak (f–h).