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Research Article

Global framework for communication of biological invasion risks

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Abstract

Biological invasions, driven by the spread of non-native species, have become a critical global issue because of their far-reaching ecological and socioeconomic impacts. Effective communication of the risks of biological invasions is essential for implementing robust policy and legislation and gaining public support for conservation efforts. However, current policies often suffer from fragmentation and ineffectiveness, largely due to inadequate risk communication and complex multi-level governance. To address this challenge, we develop a global framework designed to enhance clearer communication about biological invasion risks. The framework contextualizes key terms across three domains in invasion science: species invasiveness, risk analysis, and decision support tools. Using both diffusion-of-English and ecology-of-language paradigms, and following a three-step process involving preliminary consensus, AI querying, and ground-truthing with final consensus, we validate the framework in 70 non-English languages which, together with English, have official status in at least one country and collectively cover all 195 countries worldwide. Our findings reveal that while terminology for risk analysis is well established, terminology for species invasiveness and, especially, for decision support tools remains underdeveloped in many languages, hindering effective communication and policy implementation. Our framework underscores the importance of cultural and political neutrality. By promoting clearer risk communication among scientists, policymakers, and the public globally, we aim to reduce policy fragmentation and foster enhanced collaboration in risk mitigation. We recommend expanding multilingual decision support tools to include the full risk analysis process: risk identification, risk assessment, and risk management. This will support intergovernmental mitigation efforts and promote a unified global response to biological invasions.

Key words: citizen science, decision support tools, multi-level governance, risk analysis, species invasiveness, validation

Introduction

Biological invasions pose a major global economic burden on society and result in extensive ecological damage to native biota (Early et al. 2016; Seebens et al. 2017, 2021; Diagne et al. 2021; IPBES 2023; Haubrock et al. 2026). Considering the trans-border nature of biological invasions, effective risk communication among scientists, as informed experts, and governments, as decision-making authorities, both within and across nations, is paramount (Piria et al. 2017; Copp et al. 2021; Baquero et al. 2021). At the same time, clarity and conciseness in risk communication are essential for the general public, as public perception of risk influences governmental and regulatory actions (Vaz et al. 2017; Shackleton et al. 2019; Carter et al. 2021; Roy et al. 2024; Reeb and Heberling 2025). To gain public support for preventing and managing biological invasions, and thereby conserving native biodiversity, the message must be clear, comprehensive, and educational (Encarnação et al. 2021; Verbrugge et al. 2021). In recent years, there has been increased emphasis on the importance of including non-English publications to advance knowledge in environmental sciences (Amano et al. 2021; Angulo et al. 2021). This is particularly relevant given the cultural and societal factors influencing linguistic diversity across countries.

In invasion science, it has been shown that resolving language-related uncertainties in risk communication can be achieved by balancing two complementary linguistic paradigms: the “diffusion of English” and the “ecology of language” (Copp et al. 2021). The diffusion-of-English paradigm refers to the global dominance and widespread use of English as the primary language of science, policy, and professional communication, often functioning as a shared working language in multilingual contexts (Phillipson and Skutnabb-Kangas 1996). In contrast, the ecology-of-language paradigm examines how languages interact with their social, cultural, and environmental settings, emphasizing the importance of maintaining linguistic diversity and ensuring that scientific concepts are accurately conveyed within each local language (Haugen 1972). Together, these paradigms highlight the need to balance the practical benefits of English as a common scientific language with the necessity of developing precise, context-appropriate terminology in other languages to support effective communication with local stakeholders, managers, and policymakers. At the same time, the influence of politically and culturally laden language on the framing and reception of scientific issues is well documented in the science communication literature (Nisbet and Mooney 2007; Golebie et al. 2022).

Fostering risk communication is crucial for reducing the fragmentation of policy-making instruments and improving their application as part of intergovernmental initiatives for the management of biological invasions (Humair et al. 2014; Ricciardi et al. 2017; Pyšek et al. 2020; Roy et al. 2024). In this study, we first contextualize key terms used in invasion science across three domains: species invasiveness, risk analysis, and decision support tools. Based on this: (1) we develop a multilingual framework that includes as many languages as necessary to ensure global coverage; (2) we evaluate both similarities and differences in invasion science terms in the various languages relative to English within the context of the diffusion-of-English versus ecology-of-language paradigms; and (3) we assess the current usage of these terms in the various languages as an indicator of how well-developed, established, or standardized the terminology is within each language across the three domains. The overarching objective of the framework is to enhance communication about the risks of biological invasions among scientists, competent authorities, and the general public, both locally and globally (Table 1). This is crucial for countries where invasion science is still developing as a scientific discipline. For these countries, multi-level governance and policy-making options for the management of biological invasions will benefit from improved communication in the local official language. Enhanced global communication of the risks of biological invasions will streamline efforts to first inform and then mitigate the threats of invasive species to native ecosystems worldwide as part of intergovernmental conservation initiatives.

Table 1. Benefits of the global framework to enhance communication of biological invasion risks.

Benefit	Description
Improved accessibility	By providing terminology in multiple languages, non-English speakers can understand and engage with the material. This is crucial for reaching a broader audience, especially local communities and policymakers who may not be proficient in English.
Cultural relevance	Contextualizing key terms in invasion science to reflect cultural nuances and local contexts makes the information more relevant and easier to understand for diverse audiences. This can lead to better acceptance and implementation of policies and practices.
Consistent terminology	A standardized set of terms in multiple languages can reduce confusion and misinterpretation. This consistency is vital for effective communication among international scientists and stakeholders, ensuring that everyone is correctly informed about the risks of and management strategies for biological invasions.
Enhanced collaboration	Multilingual resources can facilitate collaboration among scientists, governments, non-governmental organizations and the public across different countries. Shared understanding and terminology can help coordinate efforts and implement best practices more efficiently.
Policy harmonization	By providing a common terminological framework, the initiative can help align national and international policies on invasive species. This can reduce policy fragmentation and foster cooperative efforts to address biological invasions more effectively.
Public engagement	Clear and accessible communication in multiple languages can raise public awareness and support for conservation efforts. Engaging local communities in their native language(s) can lead to better participation and compliance with invasive species management programmes.
Education and training	Multilingual educational materials and training programmes can help build capacity in regions that are affected by biological invasions but may lack resources and expertise. This can empower local stakeholders to take proactive measures.
Risk analysis	By expanding multilingual decision support tools, stakeholders can more effectively identify, assess and manage risks associated with biological invasions. This comprehensive approach can improve the overall effectiveness of mitigation strategies for invasive species.

Methodology

Terminological framework

We identify three terminological domains that follow a logical sequence: species invasiveness, risk analysis, and decision support tools (Figure 1). In invasion science, species invasiveness is first assessed through risk analysis, which is then supported by the implementation of decision support tools, with risk communication serving as the foundational theme.

Species invasiveness

For species invasiveness, we employ minimalist and biologically grounded terminology (Copp et al. 2005a; Iannone et al. 2020; Soto et al. 2024; Vilizzi et al. 2025b) that includes three terms: *non-native species*, *established species*, and *invasive species* (Table 2). These terms are structured hierarchically and rooted in ecological principles, reflecting the stages of a *non-native species'* invasion process, encompassing its entry, establishment, dispersal, and impact (Blackburn et al. 2011). Our definition of *invasive species* incorporates the criterion that a species must cause detectable impact – whether environmental, economic, or harm to humans (Iannone et al. 2020). This criterion underpins the categorization of a *non-native species'* invasiveness (i.e. into invasive or non-invasive) for the implementation of decision support tools (see below). For this categorization, it is crucial to

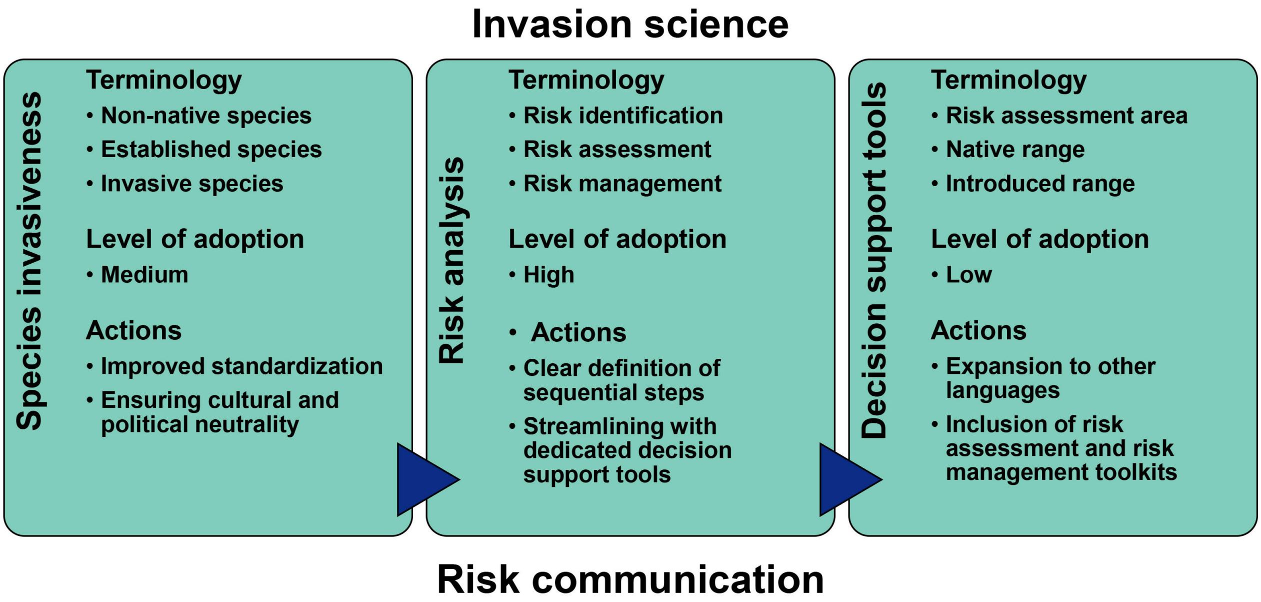

Figure 1. Schematic diagram of the framework for communicating biological invasion risks. Three domains are identified that follow a logical sequence. In invasion science, species invasiveness is first assessed through risk analysis, which is then supported by the implementation of decision support tools, with risk communication serving as the foundational theme. For each domain, the terminology used is shown alongside the level of adoption of each set of terms in both English and 70 non-English languages spoken across all 195 countries worldwide, and the respective proposed actions to be implemented.

provide sufficient and, whenever possible, literature-based evidence of impact, rather than relying solely on assumptions (Vilizzi et al. 2022a).

Amongst the alternative terms to *non-native* for which we support cautious usage are *alien*, *exotic*, *foreign*, *non-indigenous*, and *naturalized*, but not *allochthonous* – a term rooted in biology and geology (https://www.merriam-webster.com/dictionary/allochthonous). We recommend that the use of the first four terms be limited not only in the context of this study but more broadly in invasion- science publications, given their potential political and cultural bias (Iannone et al. 2020; Soto et al. 2024). As for *naturalized*, although often synonymous with *established*, its usage can be misleading due to etymology (Iannone et al. 2020) and the many definitions associated with it. These range from the historical connection to naturalization and acclimatization societies to the ambiguity surrounding the time required for a species to be considered *naturalized* in its range of introduction (Copp et al. 2005a). Taken together, these issues underscore that *established* provides a clearer, less ambiguous descriptor, while *naturalized* should be applied cautiously to prevent misinterpretation.

Risk analysis

For risk analysis, we focus on three terms: *risk identification*, *risk assessment*, and *risk management* (Table 2). We define risk analysis in invasion science as a process that consists of the above three sequential steps. Our definition of risk analysis integrates a conceptual scheme (Copp et al. 2005b; Heggum 2011) that is composite and grounded in environmental regulations (UK Defra 2011) and has been widely adopted internationally

Table 2. Definition of the invasion science terms used in the global framework (with indication of reference studies).

Term	Definition
Species invasiveness	
Non-native species	A species that is present in or arriving to an area to which it is not native (i.e. where it has no evolutionary history) either by direct human introduction or by dispersal after a biogeographic barrier is removed (Copp et al. 2005a; Iannone et al. 2020; Soto et al. 2024).
Established species	A non-native species that has formed self-sustaining populations in an area outside its native range, regardless of whether it is currently spreading (Copp et al. 2005a; Iannone et al. 2020; Soto et al. 2024).
Invasive species	A non-native species in its introduced range that spreads (actively or passively) and causes, or has the potential to cause, environmental, economic, or human-health impacts (Copp et al. 2005a; Iannone et al. 2020; Soto et al. 2024).
Risk analysis	
Risk identification	Aims to identify which non-native species (either already present or future) are likely to be invasive in a predefined risk assessment area (Copp et al. 2005b).
Risk assessment	Involves a detailed examination of the likelihood and magnitude of the impacts caused by a non-native species' introduction, establishment, dispersal and impacts (Vilizzi et al. 2022a).
Risk management	Evaluates a species' likelihood of invasiveness in view of appropriate management actions (Vilizzi et al. 2022a).
Decision support tools	
Risk assessment area	The area for which risk identification (and follow-up risk assessment, as applicable) is being conducted for one or more non-native species (Vilizzi et al. 2022a).
Native range	The biogeographic region where a species' presence is solely influenced by natural evolutionary processes, without any human intervention (Copp et al. 2005a; Iannone et al. 2020; Soto et al. 2024).
Introduced range	The biogeographical region where a species is found as a result of human intervention, whether deliberate or accidental, or where it has not naturally evolved (Copp et al. 2005a; Iannone et al. 2020; Soto et al. 2024).

(Gozlan et al. 2010; Copp et al. 2016a; Robertson et al. 2021; Vilizzi et al. 2021, 2022a, 2024). Of note, the terminology used here for risk analysis aligns with that employed in other scientific disciplines, tracing its origins back to the mid-20th century (Copp et al. 2005b).

The first step, *risk identification* involves determining which *non-native species*, given their life-history traits and ecological interactions, are likely to establish, spread, and ultimately cause ecological or socio-economic impacts in a predefined area. Identifying which *non-native species* are likely to exert detrimental ecological or socio-economic impacts is crucial for developing policies and management actions to prevent or mitigate biological invasions. This process helps decision-making authorities to prioritize resource allocation by identifying those *non-native species* with the higher likelihood of invasiveness, thereby warranting a comprehensive *risk assessment*.

The second step, *risk assessment*, involves a thorough evaluation, building on *risk identification*, of the likelihood and magnitude of risks associated with a *non-native species*' introduction, its ability to establish, its potential to disperse, and the impacts it may cause.

The final step, *risk management*, involves evaluating a *non-native species*' likelihood of invasiveness in view of the implementation of proper management actions. In this study, we consider "identification" and "screening" to describe the same initial step of the risk-analysis process; for clarity, we refer to this step consistently as *risk identification*. Our approach is the result of advocacy over two decades of research in this field (Copp 2013; Copp et al. 2005b, 2016b; Vilizzi and Piria 2022; Vilizzi et al. 2019, 2022b, 2024).

Decision support tools

For decision support tools, we focus on three terms: *risk assessment area*, *native range*, and *introduced range* (Table 2). These terms are integral components of the questionnaire and graphical user interface of the most widely employed multilingual electronic decision support tool for the *risk identification* of non-native aquatic organisms (the Aquatic Species Invasiveness Screening Kit: AS-ISK; Copp et al. 2016b, 2021) and its recent "siblings" for screening terrestrial animals (the Terrestrial Animal Species Invasiveness Screening Kit: TAS-ISK; Vilizzi et al. 2022b) and terrestrial plants (the Terrestrial Plant Species Invasiveness Screening Kit: TPS-ISK; Vilizzi et al. 2024). These second-generation, taxon-generic toolkits trace their origins back to the Australian Weed Risk Assessment (Pheloung et al. 1999) through the previous, first-generation, taxon-specific screening tools of the ISK family (Copp 2013). They are multilingual, currently supporting a total of 30 languages other than English (Vilizzi et al. 2025a). The AS-ISK has been applied worldwide and by far surpasses any other available risk screening toolkit for aquatic organisms in both the number of applications and taxa evaluated (Vilizzi and Piria 2022; Vilizzi et al. 2019, 2024). For these reasons, it has established itself as state-of-the-art resource in invasion science (Srėbalienė et al. 2019; Kourantidou et al. 2022).

Unlike *non-native range*, the term *introduced range* avoids potential ambiguity. Thus, while an *introduced species* is also non-native, a *non-native species* may not necessarily have been introduced by human activity in its *non-native range* (Iannone et al. 2020). In the ISK tools, it is essential to specify the *risk assessment area* for each species under screening, alongside the species' *native range* and *introduced range*. This information is included in the "preamble", which provides the context for the screening process and ensures compliance with European Community regulations on the prevention and management of the introduction and spread of "invasive alien species" (*sensu* Roy et al. 2018). Accordingly, the *non-native range* of a species encompasses all areas of distribution outside its *native range*, where it may or may not be introduced.

Terminology in English

We conducted online searches for five terms that are associated with alternative terminologies (Table 2; Supplementary material Table S1): *non-native species*, *established species*, *invasive species*, *risk identification*, *introduced range*. With regard to species invasiveness, the alternative terms searched were: (i) for *non-native species*: *alien species*, *exotic species*, *foreign species*, *non-indigenous species*, and *allochthonous species*; (ii) for *established* *species*: *established non-native species* and *naturalized species*; (iii) for *invasive species*: *invasive non-native species* and *invasive alien species*. For risk analysis, we compared *risk identification* with *risk screening*. For decision support tools, we compared *introduced range* with *non-native range*.

The terms non-native species, non-indigenous species, *established non-native species*, *invasive non-native species*, and *non-native range* were searched separately also as *nonnative species*, *nonindigenous species*, *established nonnative species*, *invasive nonnative species*, and *nonnative range*, respectively (i.e. without hyphen, but not as *non native species*, *non indigenous species*, established non native species, *invasive non native species*, and *non native range* as no distinction is made between hyphen and space in the searches from the online resources). The term *naturalized species* was searched separately also as *naturalised species*. In all cases, the respective number of search results was summed up.

For the searches, we used three online resources successively following standard protocol (Angulo et al. 2021): the Google search engine (https://www.google.com/), the Google Scholar database (https://scholar.google.com/), and the Web of Science platform (WoS: https://webofknowledge.com). For the term *introduced range*, the word *species* was added to the searches to restrict the number of search results to the biological sciences. Conversely, this restriction was not applied to the term *risk identification* given the well-established terminology for risk analysis across scientific disciplines (see above). For each term, we conducted searches using the exact phrase (i.e. the whole term enclosed in quotation marks), rather than searching for the individual component words. The only exception was the term *species* in *introduced range* for which separate word searches combined with Boolean operators were required. In Google Scholar, the search was across articles published at any time and of any type, including citations. In WoS, the search was across all databases. For each term, we then recorded the total number of results and the respective URL from the three online resources. All searches were done on 28/02/2025.

Inclusion of languages

To ensure global coverage, we included 71 languages spoken which, together with English, have official status in at least one country and collectively cover all 195 countries worldwide (Table S2). These countries (sovereign states) consist of the 193 United Nations (UN) member states (https://www.un.org/en/about-us/member-states) and the two UN General Assembly non-member observer states (https://www.un.org/en/about-us/non-member-states). We excluded Antarctica despite territorial claims, as no single political entity owns the continent, and there are no recognized nations within it. For each of the 195 countries, we retrieved information about the official language(s) spoken (https://www.cia.gov/the-world-factbook/field/languages/) for inclusion. Languages were included according to five criteria (see Appendix 1).

Validation

Implementation involved choice of the experts followed by a three-step validation of the terminology in the non-English languages and finally by an online search of the resulting terms. The three sets of terms in English defined in this study (Table 2), for a total of nine terms, were contributed in each of the 70 non-English languages included above. There were 657 terms in total as three languages (Bosnian, Montenegrin, Serbian) are spelt in both Latin and Cyrillic.

Choice of experts

In total, 138 native speakers of the assigned language(s), all co-authors of this study, contributed the terms (Table S3). The contributors included 136 biologists, most with expertise in invasion science although not all specializing in ecological risk analysis, and two language experts (H.T. and V.V.). Because this study spans a very wide linguistic range, including contributions from biologically under-represented and remote regions, it was not always possible to recruit native speakers with both domain-specific and linguistic expertise, and we therefore relied on the best-qualified native-speaking biologists available. A minimum of two experts contributed the terms in each language, and in the case of Greek, Spanish, Portuguese, and Urdu there were three experts. Of the experts, 49 have been involved for several years in the translation of the graphical user interface and questionnaire of the multilingual decision support tools for *risk identification* (Copp et al. 2016b, 2021; Vilizzi et al. 2022b, 2024, 2025a) (Table S3).

First-step validation – Preliminary consensus

Three tables with the three sets of terms in English were circulated amongst the experts, accompanied by detailed instructions regarding the terminological context and definition (as outlined in Table 2, including all references in support). The experts contributed the terms in their respective native language by conducting a thorough search of the invasion science literature in their language, including any country-level legislation on non-native (invasive) species, if available (Table S4). This allowed finding the “best” match with the terminology in English. In cases where literature resources were lacking, experts applied a structured expert-judgement process, discussing available evidence and reaching consensus on the most appropriate term to use. The terms provided in the different languages were then refined and finalized between or among the experts through as many iterations as necessary to achieve preliminary consensus. This involved reaching a mutual agreement on the most appropriate terms to use. Throughout the process, the experts were instructed to follow the rationale and scope for the definition and contextualization of the terms in English, thus following the diffusion-of-English paradigm. At the same time, they were encouraged to consider any language-specific nuances and constraints, aligning with the ecology-of-language paradigm. Special attention was given to the terms *non-native species*, *risk identification*, *native range*, and *introduced range* for which the experts were asked to explain any discrepancies from the English terms, whenever applicable.

Second-step validation – AI querying

Based on the resulting 657 candidate terms from the first-step validation, we employed ChatGPT (OpenAI 2025) to validate each term at the scientific, academic, policymaker, and ecological levels in each language. ChatGPT was selected because of its broad multilingual capabilities and its emerging use in research workflows (e.g. Biswas 2023; Turobov et al. 2024). For each language, the same standardized two questions were submitted (see Appendix 1).

AI-assisted terminology retrieval was conducted via the ChatGPT web interface using default system settings. Outputs were generated using fixed prompts applied consistently across all languages and terms, archived verbatim, and subsequently subjected to expert ground-truthing and consensus validation. As the objective of this study was not to benchmark raw AI performance but to assess the dependability of AI-assisted terminology within a validated analytical framework, reproducibility was ensured through standardized prompts, documented query timing, and expert-controlled validation rather than reliance on uncurated model outputs. All AI-generated outputs were reviewed, as large language models may produce inaccurate, ambiguous, or culturally mismatched responses (Biswas 2023; Turobov et al. 2024).

Third-step validation – Ground-truthing with final consensus

If the AI-generated response was judged to be of low validity, experts were asked either (i) to propose an alternative term, which would then be evaluated again following the same validation process from the beginning, or (ii) to retain their original term and justify this choice on the basis of published evidence or expert judgement. In cases where an alternative term was proposed, follow-up queries were submitted to ChatGPT and the new outputs were reviewed until the experts reached agreement on the most appropriate term.

This final agreement constituted the final consensus, which differed from the initial consensus established before the AI validation. The initial consensus reflected the experts' first choice of term, whereas the final consensus incorporated both expert judgement and the results of the AI-supported evaluation – including any revisions made to resolve discrepancies between expert opinion and AI output.

Upon completion of the AI response, ground-truthing by expert opinion and reaching final consensus, 657 AI reports were generated and categorized into high (rank = 3), medium (rank = 2) and low (rank = 1) validity (Figure S1; Appendix 2). By summing the ranks over the nine terms for each language, German had the highest total rank (26) and Amharic and Norwegian the lowest total rank (19) (Figure S2). This meant that the AI validation was most dependable for the former language and least for the latter languages. By summing the ranks over the 70 non-English languages for each term, those related to species invasiveness (mainly, *non-native species* and *invasive species*) and to risk analysis (*risk identification*, *risk assessment*, *risk management*) had overall higher total ranks, whereas *established species* and the terms pertaining to decision support tools (*risk assessment area*, *native range*, *introduced range*) had lower total ranks (Figure S3).

Online searches

Based on the resulting 657 terms, plus the original nine English terms (Table 2), we conducted an online search for each of them using the same method as for the search of the terminology in English. For the languages with declension (i.e. grammatical forms of nouns), the nominative case was used. For the terms *native range* and *introduced range*, the word *species* was added to the searches to restrict the number of results to the biological sciences. Conversely, this restriction was not applied to the terms *risk identification*, *risk assessment*, and *risk management*, given the well-established terminology for risk analysis across scientific disciplines, nor was it applied to *risk assessment area* being also a generic term.

In Google, the searches were limited to web pages in the respective language if available (41 languages in total: Arabic, Armenian, Belarusian, Bulgarian, Catalan, Chinese, Croatian, Czech, Danish, Dutch, Estonian, Filipino, Finnish, French, German, Greek, Hebrew, Hindi, Hungarian, Icelandic, Indonesian, Italian, Japanese, Korean, Latvian, Lithuanian, Norwegian, Persian, Polish, Portuguese, Romanian, Russian, Serbian, Slovak, Slovenian, Spanish, Swedish, Thai, Turkish, Ukrainian, Vietnamese), else the search was without constraints (29 languages in total: Albanian, Amharic, Azerbaijani, Bengali, Bosnian, Burmese, Dari, Dhivehi, Dzongkha, Faroese, Georgian, Kazakh, Khmer, Kyrgyz, Lao, Macedonian, Malay, Mongolian, Montenegrin, Nepali, Pashto, Sinhala, Somali, Tajik, Tamil, Tigrinya, Turkmen, Urdu, Uzbek). In the case of Bosnian and Montenegrin, due to some terms being identical to Serbian, the searches were restricted in both cases to the Bosnia and Herzegovina region (noting that no Montenegrin region is available as an option in the Google searches).

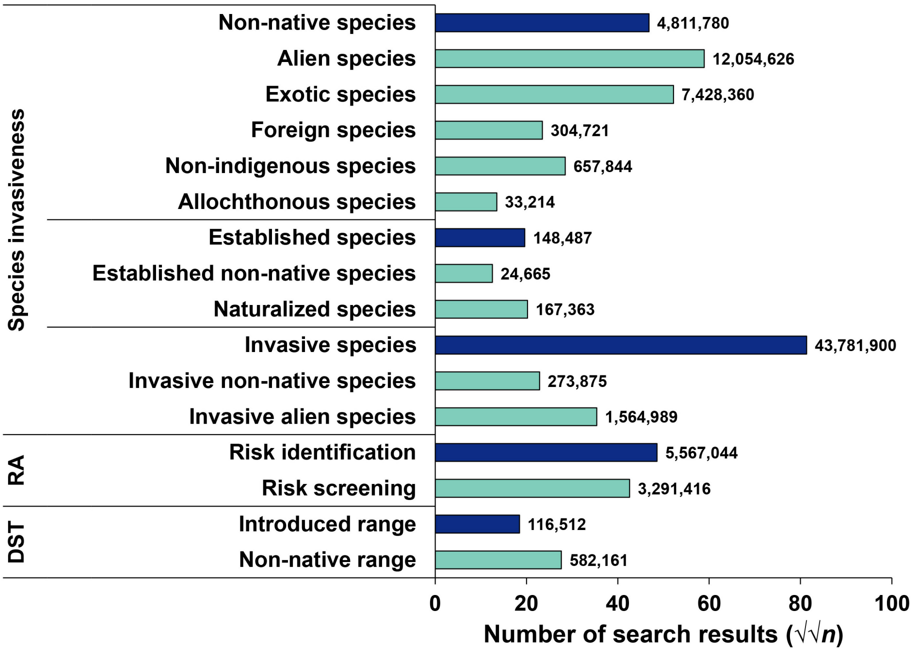

Figure 2. Double square-root transformed number (√√*n*) of Google, Google Scholar, and Web of Science search results for five terms used in invasion science and adopted as part of the present multilingual framework (dark blue bars) alongside their alternative terms (turquoise bars) across three domains (Species invasiveness; RA = Risk analysis; DST = Decision support tools). For the terms including *non-native*, the number of results also includes that for searches of *nonnative*, for *non-indigenous* also that of searches for *nonindigenous*, and for *naturalized* also that of searches for *naturalised*. The raw number of search results for each term is shown.

To account for the variability in the Google search results, a first search of all terms was done by the first author based in Poland (21–23/02/2025) and then independently by each of the experts based outside of Poland (28/02/2025 to 06/03/2025) in their respective language. The results from both searches were then averaged over and the mean number of results for each term (rounded to the nearest integer) was obtained. As a metric of variation, we computed for each term the ratio between the number of results from the first author's search and that from the experts' search (set equal to 1 in case of 0 results for both searches). The ratio ranged from a minimum of 0 to a maximum of 4.62 (mean = 1.01 ± 0.02) (Appendix 3).

As per the terminology in English, in Google Scholar the search was across articles published at any time and of any type, including citations, and in WoS across all databases. For each term, we then recorded the number of results and the respective URL from the three online resources (Appendix 4).

Alongside the best-matching term for *non-native species*, labelled as the "preferred term" to satisfy, whenever possible, the requirements of lexicon neutrality (meaning the use of terminology that avoids political, cultural, or value-laden connotations: Table 2; Figure 2), the "most common" term used in each language to refer to a *non-native species* (in some cases identical to the preferred term) was provided in each of the 70 non-English languages. Searches in the three online resources were then made and the number of results and respective URL for each term from the three online resources were recorded (Appendix 5). All searches were done on 25/02/2025.

Following the searches, we recorded the total number of combined search results for each term across the three online resources, and the languages were ranked according to these total counts. The ranking was then applied to countries based on the most commonly spoken official language.

Analytical methods

As the total number of results (i.e. summed over the three online searches) for each of the 657 non-English terms spanned 7 orders of magnitude, these were ranked from 1 (≤ 10) to 8 (> 10,000,000). Based on the ranks, the resulting matrix was subjected to a cluster analysis. Using a Euclidean distance, a hierarchical cluster analysis was performed in PRIMER 7 (Clarke and Gorley 2015) with group average cluster mode, 9,999 permutations, and significance level at $\alpha = 0.05$ for the clusters. Plotting of the heatmap was done using the package "pheatmap" in R v4.4.0 (R Core Team 2025).

Results

Context and global coverage

In English, analysis of alternative terms to the ones adopted in this study revealed discernible patterns (Figure 2; Table S1). For species invasiveness, the terms *alien species* and *exotic species* were more prevalent than *non-native species*, with *non-indigenous species* and *foreign species* being less often employed, and even less so *allochthonous species*. The term *non-native species* represented 19.0% of the search results, with the other 80.9% including terms generally regarded as not politically or culturally neutral, and only 0.1% including the term *allochthonous*. Conversely, the number of search results for *established species* and *naturalized species* was similar overall, whereas *established non-native species* had limited recorded instances. Overall, *invasive species* was the most widely used term, followed by *invasive alien species*, whereas *invasive non-native species* appeared least frequently. For risk analysis, the term *risk identification* was more common than *risk screening*. For decision support tools, the number of search results for *introduced range* was lower than that for *non-native range*.

The terms were contributed and validated by the consensus- and AI-based approach in 70 non-English languages, which together with English are officially spoken across all 195 countries worldwide (Table S2). The framework applies in one of the 71 languages (including English) to 164 countries, in two languages to 24 countries, in three languages to six countries, and in four languages to one country. Based on the 31 languages, including English, in which the decision support tools for *risk identification* are currently available, these can be employed in the official language of 166 countries, representing 85% of the 195 countries worldwide (Table S2; Figure S4).

Dual-paradigm approach

For species invasiveness (Table 3), the terms for *established species* and *invasive species* as contributed in the 70 non-English languages were straightforward, unlike *non-native species*. In 47 languages, a term equivalent to *non-native species* (as per the original English) was used, and in 10 languages (Albanian, Bosnian, Greek, Italian, Latvian, Macedonian, Montenegrin, Romanian, Russian, Serbian) this was equivalent to *allochthonous species*. For the other 13 languages, a term equivalent to *imported species* was employed in Icelandic, and a term equivalent to *foreign species* was employed in Estonian, Finnish, and Swedish, though in both cases without negative political or cultural connotation. In the other nine languages (Armenian, Faroese, Kazakh, Khmer, Nepali, Tajik, Thai, Ukrainian, Vietnamese), a term equivalent to *alien species* was retained as the most commonly used. Apart from the latter languages, in another 17, the preferred term for *non-native species* to satisfy the criteria of lexicon neutrality was the same as the most commonly used term (Table S5). In the remaining 47 languages, the preferred and most common terms for *non-native species* differed, with the number of literature search results for the most common term (as often used in legislation: Table S4) being up to four orders of magnitude higher than those of the preferred term.

For risk analysis (Table 4), provision of the three terms for *risk identification*, *risk assessment* and *risk management* was straightforward in all 70 non-English languages. In 61 of these, a term equivalent to *risk identification* was used, while in the other nine (Bulgarian, Danish, Faroese, German, Icelandic, Norwegian, Swedish, Turkish, Ukrainian), it translated to *risk screening*.

For decision support tools (Table 5), there were notable differences in the terms used for *risk assessment area*, *native range*, and *introduced range*. The distinction between *area* and *range* (as in English) was preserved in 41 languages. Conversely, in 25 languages, no such differentiation was made across the three terms, and in four languages, *area* and *range* were translated differently. Additionally, in 12 languages, *range* was equivalent to *distribution (area)* in the context of *native range*, *introduced range* or both. In another three languages, the term *introduced* was equivalent to *non-native*, *alien* or *allochthonous*.

Adoption of terminology

Based on the number of search results for each of the nine terms, there was marked variation across the 70 non-English languages, with differences

Table 3. Terminology for species invasiveness. Terms (singular voice) pertaining to species invasiveness (Table 2) contributed by 138 authors of this study (Table S3) in 70 non-English languages that, alongside English (ID = 1), are officially spoken across all 195 countries worldwide (Table S2). Case refers to *non-native species* translating in English to: A = *allochthonous species*; B = *non-native species* (as per the original English); C = *alien species*; D = *foreign species* (though not regarded as politically or culturally laden); E = *imported species*. AI-validation of the terms in Appendix 2. For each term, the number of search results from Google, Google Scholar and Web of Science and the respective URL are provided in Appendix 4.

ID	Language	Case	Non-native species	Established species	Invasive species
2	Albanian	A	Lloj allokton	Lloj i vendosur	Lloj invaziv
3	Amharic	B	አገር በቀል ያልሆነ ዝርያ	የተቋቋመ ዝርያ	ወራሪ ዝርያ
4	Arabic	B	نوع غير أصلي	نوع مستقر	نوع غازي
5	Armenian	C	Օտարածին տեսակ	Հիմնավորված տեսակ	Ինվազիվ տեսակ
6	Azerbaijani	B	Yerli olmayan növ	Oturuşmuş növ	İnvaziv növ
7	Belarusian	B	Неабарыгенны від	Укаранёны від	Інвазіўны від
8	Bengali	B	বিদেশি প্রজাতি	প্রতিষ্ঠিত প্রজাতি	ক্ষতিকর প্রজাতি
9	Bosnian (Latin)	A	Alohtona vrsta	Uspostavljena vrsta	Invazivna vrsta
9	Bosnian (Cyrillic)	A	Алохтона врста	Успостављена врста	Инвазивна врста
10	Bulgarian	B	Неместен вид	Установен вид	Инвазивен вид
11	Burmese	B	ဒေသပြင်ပ မျိုးစိတ်	အခြေကျ မျိုးစိတ်	ကျူးကျော် မျိုးစိတ်
12	Catalan	B	Espècie no nativa	Espècie establerta	Espècie invasora
13	Chinese	B	非本地种	建群种	入侵种
14	Croatian	B	Nezavičajna vrsta	Uspostavljena vrsta	Invazivna vrsta
15	Czech	B	Nepůvodní druh	Etablovaný druh	Invazní druh
16	Danish	B	Ikke-hjemmehørende art	Etableret art	Invasiv art
17	Dari	B	نوع غیر بومی	نوع تثبیت شده	نوع تهاجمی
18	Dhivehi	B	އެ ސަރަހައްދަކަށް ނިސްބަތްނުވާ ނަސްލު	ތަނުގައި ގާއިމުވެފައިވާ ނަސްލު	ފެތުރޭ ނަސްލު
19	Dutch	B	Niet-inheemse soort	Gevestigde soort	Invasieve soort
20	Dzongkha	B	སྐྱེས་ལུང་གི་ རིགས་སྣ་མེན་མི།	རིགས་སྣ་ གཞི་བཙུགས་ བཙུགས་པ།	རང་བཞིན་མེན་པའི་ བཙན་འཛུལ་གྱི་རིགས།
21	Estonian	D	Võõrliik	Kodunenud liik	Invasiivne liik
22	Faroese	C	Fremmant slag	Búfest slag	Innræsið slag
23	Filipino	B	Dayuhang species	Nakapagtatag na species	Invasive na species
24	Finnish	D	Vieraslaji	Vakiintunut laji	Invasiivinen laji
25	French	B	Espèce non-native	Espèce établie	Espèce envahissante
26	Georgian	B	არაადგილობრივი სახეობა	დამკვიდრებული სახეობა	ინვაზიური სახეობა
27	German	B	Nicht einheimische Art	Etablierte Art	Invasive Art
28	Greek	A	Αλλόχθονο είδος	Εγκατεστημένο είδος	Εισβολικό είδος
29	Hebrew	B	מין לא מקומי	מין מבוסס	מין פולש
30	Hindi	B	गैर देशी प्रजाति	स्थापित प्रजाति	आक्रामक प्रजाति
31	Hungarian	B	Nem őshonos faj	Megtelepedett faj	Inváziós faj
32	Icelandic	E	Innflutt tegund	Ílend tegund	Ágeng tegund
33	Indonesian	B	Spesies bukan asli	Spesies yang sudah mapan	Spesies invasif
34	Italian	A	Specie alloctona	Specie stabilizzata	Specie invasiva
35	Japanese	B	外来種	定着種	侵略的種
36	Kazakh	C	Бөгде түр	Қалыптасқан түр	Инвазивті түр
37	Khmer	C	ប្រភេទក្រៅស្រុក ឬតំបន់	បានបង្កើតឱ្យមានប្រភេទថ្មី	ប្រភេទរាតត្បាត
38	Korean	B	비토착종	정착종	침입종
39	Kyrgyz	B	Жергиликтүү эмес түр	Ылайыкташкан түр	Инвазивдүү түр
40	Lao	B	ຊະນິດພັນຕ່າງຖິ່ນ	ຊະນິດທີ່ຕັ້ງຖິ່ນຖານ	ຊະນິດບຸກລຸກ
41	Latvian	A	Alohtona suga	Iedzīvojusies suga	Invazīva suga
42	Lithuanian	B	Nevietinė rūšis	Įsitvirtinusi rūšis	Invazinė rūšis
43	Macedonian	A	Алохтон вид	Одомаќинет вид	Инвазивен вид
44	Malay	B	Spesies bukan asal	Spesies tetap	Spesies invasif
45	Mongolian	B	Уугуул бус зүйл	Нутагшсан зүйл	Түрэмгийлэгч зүйл
46	Montenegrin (Latin)	A	Alohtona vrsta	Odomaćena vrsta	Invazivna vrsta
46	Montenegrin (Cyrillic)	A	Алохтона врста	Одомаћена врста	Инвазивна врста
47	Nepali	C	बाह्य प्रजाति	स्थापित प्रजाति	मिचाहा प्रजाति
48	Norwegian	B	Ikke-naturlig forekommende art	Etablert art	Invaderende art
49	Pashto	B	غير بومي نوع	تثبيت شوي نوع	بريد ګرې نوع
50	Persian	B	گونه غیربومی	گونه استقرار یافته	گونه مهاجم
51	Polish	B	Gatunek nierodzimy	Gatunek zadomowiony	Gatunek inwazyjny
52	Portuguese	B	Espécie não-nativa	Espécie estabelecida	Espécie invasora

Table 3. (continued).

ID	Language	Case	Non-native species	Established species	Invasive species
53	Romanian	A	Specie alohtonă	Specie stabilită	Specie invazivă
54	Russian	A	Аллохтонный вид	Обосновавшийся вид	Инвазивный вид
55	Serbian (Latin)	A	Alohtona vrsta	Uspostavljena vrsta	Invazivna vrsta
55	Serbian (Cyrillic)	A	Алохтона врста	Успостављена врста	Инвазивна врста
56	Sinhala	B	විදේශජ විශේෂය	ස්ථාවරවූ විශේෂය	ආක්‍රමණශීලී විශේෂය
57	Slovak	B	Nepôvodný druh	Etablovaný druh	Invázny druh
58	Slovenian	B	Tujerodna vrsta	Ustaljena vrsta	Invazivna vrsta
59	Somali	B	Nooc aan dhalad ahayn	Nooc la keenay oo qabatimay	Nooc duullaan ah
60	Spanish	B	Especie no nativa	Especie establecida	Especie invasora
61	Swedish	D	Främmande art	Etablerad art	Invasiv art
62	Tajik	C	Намуди бегона	Намуди муқарраришуда	Намуди инвазивӣ
63	Tamil	B	பூர்வீகமற்ற இனம்	நிலைநாட்டப்பட்ட இனம்	ஆக்கிரமிப்பு இனம்
64	Thai	C	ชนิดพันธุ์ต่างถิ่น	ชนิดพันธุ์ที่ตั้งถิ่นฐาน	ชนิดพันธุ์รุกราน
65	Tigrinya	B	ዘይመበቆላዊ ዓሌት	ዝተመስረተ ዓሌት	ወራሪ ዓሌት
66	Turkish	B	Yerli olmayan tür	Yerleşik tür	İstilacı tür
67	Turkmen	B	Ýerli däl görnüş	Ýerleşen görnüş	Inwaziw görnüş
68	Ukrainian	C	Чужорідний вид	Укорінений вид	Інвазивний вид
69	Urdu	B	غیر مقامی سپیشیز	مستحکم سپیشیز	تصرف پزیر سپیشیز
70	Uzbek	B	Mahalliy bo'lmagan tur	O'rnashgan tur	Bosqinchi tur
71	Vietnamese	C	Loài ngoại lai	Loài đã thiết lập	Loài xâm lấn

spanning up to six orders of magnitude (Figure 3; Table S6). The terms related to risk analysis were overall well represented in almost all languages. This was true also for the terms pertaining to species invasiveness in several languages, albeit to a lesser extent. Conversely, a substantially lower number of results was found for the terms related to decision support tools in almost all languages. There were three main language clusters, with Arabic, Chinese, French, Italian, Japanese, Korean, Portuguese, Spanish and Vietnamese separated from the least represented languages (Burmese, Dhivehi, Dzongkha, Kazakh, Sinhala, Tigrinya, Turkmen), and with all other languages in between.

When ranked based on the total number of search results and including English, unsurprisingly this language surpassed all others by one order of magnitude (Figure 4; Table S6). Overall, the grouping seen in the clusters was preserved, with Chinese, French, German, Japanese, Portuguese, Spanish, and Thai in the highest rank for the non-English languages, followed by Arabic, Hindi, Indonesian, Italian, Malay, Swedish, and Turkish in the second highest rank. On the other side of the spectrum, Dzongkha had no search results and Dhivehi had only six.

Based on the languages with the highest number of search results, a relatively well-established terminology is present in English- and Spanish-speaking countries across the Americas, Africa and Australasia as well as in Pakistan, but also in China and Japan (Figure 5). However, this is related mainly to risk analysis and, to a lesser extent, species invasiveness, but considerably less to decision support tools. Conversely, several countries in Eastern Europe, Central and South Asia, East Asia, and the Horn of Africa show a comparatively lower development of terminology, which in some cases is near absent.

Table 4. Terminology for risk analysis. Terms pertaining to risk analysis (Table 2) contributed by 138 authors of this study (Table S3) in 70 non-English languages that, alongside English (ID = 1), are officially spoken across all 195 countries worldwide (Table S2). Case: A = translating as per the original English; B = *risk identification* translating as *risk screening*. AI-validation of the terms in Appendix 2. For each term, the number of search results from Google, Google Scholar and Web of Science and the respective URL are provided in Appendix 4.

ID	Language	Case	Risk identification	Risk assessment	Risk management
2	Albanian	A	Identifikimi i rrezikut	Vleresimi i rrezikut	Menaxhimi i rrezikut
3	Amharic	A	ስጋት መለየት	የስጋት ግምገማ	የስጋት አስተዳደር
4	Arabic	A	تحديد المخاطر	تقييم المخاطر	إدارة المخاطر
5	Armenian	A	Ռիսկերի բացահայտում	Ռիսկերի գնահատում	Ռիսկերի կառավարում
6	Azerbaijani	A	Riskin müəyyən olunması	Risk qiymətləndirilməsi	Riskin idarə edilməsi
7	Belarusian	A	Ідэнтыфікацыя рызыкі	Ацэнка рызыкі	Кіраванне рызыкай
8	Bengali	A	ঝুঁকি চিহ্নিতকরণ	ঝুঁকি নিরূপণ	ঝুঁকি ব্যবস্থাপনা
9	Bosnian (Latin)	A	Identifikacija rizika	Procjena rizika	Upravljanje rizikom
9	Bosnian (Cyrillic)	A	Идентификација ризика	Процјена ризика	Управљање ризиком
10	Bulgarian	B	Скрининг на риска	Оценка на риска	Управление на риска
11	Burmese	A	အန္တရာယ်အလားအလာ သတ်မှတ်ခြင်း	အန္တရာယ်အလားအလာ စိစစ်ခြင်း	အန္တရာယ်အလားအလာ စီမံခန့်ခွဲခြင်း
12	Catalan	A	Identificació de riscos	Avaluació de riscos	Gestió de riscos
13	Chinese	A	风险识别	风险评估	风险管理
14	Croatian	A	Identifikacija rizika	Procjena rizika	Upravljanje rizicima
15	Czech	A	Identifikace rizika	Hodnocení rizika	Řízení rizika
16	Danish	B	Risikoscreening	Risikovurdering	Risikostyring
17	Dari	A	شناسایی خطر	ارزیابی خطر	مدیریت خطر
18	Dhivehi	A	[illegible]	[illegible]	[illegible]
19	Dutch	A	Risico-identificatie	Risicobeoordeling	Risicobeheer
20	Dzongkha	A	ཉེན་ཁ་དབྱེ་དཔྱད	ཉེན་ཁ་ བརྟག་ཞིབ།	ཉེན་ཁ་ འཛིན་སྐྱོང་།
21	Estonian	A	Riski tuvastamine	Riskihinnang	Riskijuhtimine
22	Faroese	B	Váðaeyðmerking	Váðameting	Váðastýring
23	Filipino	A	Pagtukoy ng panganib	Pagtatasa ng panganib	Pamamahala ng panganib
24	Finnish	A	Riskien tunnistaminen	Riskinarviointi	Riskienhallinta
25	French	A	Identification des risques	Évaluation des risques	Gestion des risques
26	Georgian	A	რისკის იდენტიფიკაცია	რისკის შეფასება	რისკის მართვა
27	German	B	Risikoscreening	Risikobewertung	Risikomanagement
28	Greek	A	Αναγνώριση κινδύνου	Αξιολόγηση κινδύνου	Διαχείριση κινδύνου
29	Hebrew	A	זיהוי סיכונים	הערכת סיכונים	ניהול סיכונים
30	Hindi	A	जोखिम पहचान	जोखिम आकलन	जोखिम प्रबंधन
31	Hungarian	A	Kockázatazonosítás	Kockázatértékelés	Kockázatkezelés
32	Icelandic	B	Áhættuskimun	Áhættumat	Áhættustýring
33	Indonesian	A	Identifikasi risiko	Penilaian risiko	Manajemen risiko
34	Italian	A	Individuazione del rischio	Valutazione del rischio	Gestione del rischio
35	Japanese	A	リスクの洗い出し	リスクアセスメント	リスク管理
36	Kazakh	A	Тәуекел анықтауы	Тәуекел бағалауы	Тәуекел басқаруы
37	Khmer	A	ការកំណត់ហានិភ័យ	ការវាយតម្លៃហានិភ័យ	ការគ្រប់គ្រងហានិភ័យ
38	Korean	A	위험성 식별	위험성 평가	위험성 관리
39	Kyrgyz	A	Тобокелдиктерди аныктоо	Тобокелдиктерди баалоо	Тобокелдиктерди башкаруу
40	Lao	A	ການກຳນົດຄວາມສ່ຽງ	ການປະເມີນຄວາມສ່ຽງ	ການຄຸ້ມຄອງຄວາມສ່ຽງ
41	Latvian	A	Riska identifikācija	Riska novērtējums	Riska menedžments
42	Lithuanian	A	Rizikos nustatymas	Rizikos vertinimas	Rizikos valdymas
43	Macedonian	A	Препознавање на ризик	Проценка на ризик	Управување со ризик
44	Malay	A	Pengenalpastian risiko	Penilaian risiko	Pengurusan risiko
45	Mongolian	A	Эрсдэлийн тодорхойлолт	Эрсдэлийн үнэлгээ	Эрсдэлийн удирдлага
46	Montenegrin (Latin)	A	Identifikacija rizika	Procjena rizika	Upravljanje rizikom
46	Montenegrin (Cyrillic)	A	Идентификација ризика	Процјена ризика	Управљање ризиком
47	Nepali	A	जोखिम पहिचान	जोखिम मूल्याङ्कन	जोखिम व्यवस्थापन
48	Norwegian	B	Risikoscreening	Risikovurdering	Risikohåndtering
49	Pashto	A	د خطر پېژندنه	د خطر ارزونه	د خطر مدیریت
50	Persian	A	شناسایی خطر	ارزیابی خطر	مدیریت خطر
51	Polish	A	Identyfikacja ryzyka	Ocena ryzyka	Zarządzanie ryzykiem
52	Portuguese	A	Identificação de risco	Avaliação de risco	Gestão de risco
53	Romanian	A	Identificarea riscurilor	Evaluarea riscurilor	Gestionarea riscurilor

Table 4. (continued).

ID	Language	Case	Risk identification	Risk assessment	Risk management
54	Russian	A	Идентификация риска	Оценка риска	Управление риском
55	Serbian (Latin)	A	Identifikacija rizika	Procena rizika	Upravljanje rizikom
55	Serbian (Cyrillic)	A	Идентификација ризика	Процена ризика	Управљање ризиком
56	Sinhala	A	අවදානම හඳුනාගැනීම	අවදානම ඇගැයීම	අවදානම කළමනාකරණය
57	Slovak	A	Identifikácia rizika	Vyhodnocovanie rizika	Manažment rizika
58	Slovenian	A	Prepoznavanje tveganja	Ocena tveganja	Obvladovanje tveganja
59	Somali	A	Astaynta halista	Qiimaynta halista	Maaraynta halista
60	Spanish	A	Identificación de riesgo	Evaluación de riesgo	Gestión de riesgo
61	Swedish	B	Riskscreening	Riskbedömning	Riskhantering
62	Tajik	A	Муайян кардани хатар	Баҳодиҳии хатар	Идоракунии хатар
63	Tamil	A	இடர் திரையிடல்	இடர் மதிப்பீடு	இடர் மேலாண்மை
64	Thai	A	การระบุความเสี่ยง	การประเมินความเสี่ยง	การจัดการความเสี่ยง
65	Tigrinya	A	ስግኣት ምልላይ	ግምገማ ስግኣት	ምሕደራ ስግኣት
66	Turkish	B	Risk taraması	Risk değerlendirmesi	Risk yönetimi
67	Turkmen	A	Howpy anyklamak	Howpy bahalandyrmak	Howpy dolandyrmak
68	Ukrainian	B	Скринінг ризику	Оцінка ризику	Управління щодо ризику
69	Urdu	A	خطرے کی تشخیص	خطرے کی جانچ	خطرے کا انتظام
70	Uzbek	A	Xavfni aniqlash	Xavfni baholash	Xavf boshqaruvi
71	Vietnamese	A	Sàng lọc nguy cơ	Đánh giá nguy cơ	Quản lý nguy cơ

Of the 195 countries worldwide, 145 are members and 48 are observers of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (IPBES 2023) (Table S2). Based on this study, 19 countries with a total number of search results at ≤ 10,000—an *ad hoc* threshold for under-representation of terminology—are members of the IPBES (Figure S5).

Discussion

This study reaffirmed the higher prevalence in English of the terms *alien species* and *exotic species* over *non-native species* (Soto et al. 2024). These terms, along with *non-indigenous species*, are often used interchangeably, in some cases either to avoid repetition or due to inconsistent scientific prose. Despite ongoing efforts to standardize terminology for widely agreed-upon standards, we argue that the widespread usage of terms associated with species invasiveness and labelled as carrying negative connotations or as being ambiguous is unlikely to diminish noticeably in the near future. This is clear in the well-established usage of the term "invasive alien species" by the IPBES (IPBES 2023) as well as by the European Commission, the Convention on Biological Diversity, the United Nations Sustainable Development Goals and the International Union for Conservation of Nature (Soto et al. 2024). As shown in this study, this term is well represented in the scientific literature despite its redundancy and alleged political non-neutrality. Regardless, we suggest that achieving consensus on terminology for invasion science may be more effectively pursued by reconciling views from both advocates of standardization (Soto et al. 2024) and proponents of linguistic "liberalism", meaning the flexibility to allow languages to select or adapt terms in ways that best fit their linguistic structures (Hodges et al. 2008), as recently re-emphasized (Fusco et al. 2024). Therefore,

Table 5. Terminology for decision support tools. Terms pertaining to decision support tools (Table 2) contributed by 138 authors of this study (Table S3) in 70 non-English languages that, alongside English (ID = 1), are officially spoken across all 195 countries worldwide (Table S2). Case: A = *area* and *range* translating across the three terms as per the original English; B = *area* and *range* translating the same across the three terms; C = *area* and *range* translating differently across all three terms; D = *range* translating to *distribution (area)* in *native range* or *introduced range* or both; E = In *introduced range*, *introduced* translating to *non-native*, *alien* or *allochthonous*. AI-validation of the terms in Appendix 2. For each term, the number of search results from Google, Google Scholar and Web of Science and the respective URL are provided in Appendix 4.

ID	Language	Case(s)	Risk assessment area	Native range	Introduced range
2	Albanian	A	Zona e vlerësimit të rrezikut	Vendi i origjinës	Vendi i introduktimit
3	Amharic	B	የስጋት ግምገማ አካባቢ	ተፈጥሮአዊ አካባቢ	የመጤ አካባቢ
4	Arabic	A	منطقة تقييم المخاطر	النطاق الأصلي	النطاق المدخل
5	Armenian	A	Ռիսկերի գնահատման տարածք	Բնական տարածվածության շրջան	Ներմուծման տարածք
6	Azerbaijani	A	Risk qiymətləndirme arealı	İlkin areal	İntroduksiya olunmuş areal
7	Belarusian	A	Зона ацэнкі рызыкі	Натыўны арэал	Набыты арэал
8	Bengali	A	ঝুঁকি নিরূপণের ক্ষেত্র	দেশজ পরিসর	প্রবর্তিত পরিসর
9	Bosnian (Latin)	C, D	Područje procjene rizika	Izvorni areal rasprostranjenja	Rasprostranjenje izvan izvornog areala
9	Bosnian (Cyrillic)	C, D	Подручје процјене ризика	Изворни ареал распрострањења	Распрострањење изван изворног ареала
10	Bulgarian	A	Област на оценка на риска	Нативен ареал	Ареал на интродукция
11	Burmese	A	အန္တရာယ်အလားအလာ စိစစ်သည့် နယ်ပယ်	ဒေသမျိုးများကျက်စားရာနယ်မြေ	ဒေသပြင်ပမျိုးစိတ်များ ဝင်ရောက်ရှင်သန်ရာနယ်မြေ
12	Catalan	A	Àrea d’avaluació de riscos	Rang natiu	Rang introduït
13	Chinese	A	风险评估区域	原产地	引入地
14	Croatian	A, D	Područje procjene rizika	Zavičajna rasprostranjenost	Nezavičajna rasprostranjenost
15	Czech	A	Oblast hodnocení rizika	Původní areál	Introdukovaný areál
16	Danish	A, D	Risikovurderingsområde	Naturlig udbredelse	Introduceret udbredelse
17	Dari	A	ساحه ارزیابی خطر	محدوده بومی	محدوده معرفی شده
18	Dhivehi	A	[illegible]	[illegible] އިމު	[illegible] އިމު
19	Dutch	B	Risicobeoordelingsgebied	Inheems verspreidingsgebied	Introductiegebied
20	Dzongkha	A	ཉེན་ཁ་ བརྟག་ཞིབ་ འབད་སའི་ས་གནས།	རང་བཞིན་གྱི་གནས་སའི་ས་གོ	གསར་གཏོད་འབད་ཡོད་པའི་ས་གོ
21	Estonian	A, E	Riskihinnangu piirkond	Looduslik levila	Levila võõrliigina
22	Faroese	A	Øki fyri váðameting	Natúrlig útbreiðsla	Innslødd útbreiðsla
23	Filipino	A	Lugar ng pagtatasa ng panganib	Introdus na saklaw	Katutubong saklaw
24	Finnish	B	Riskinarviointialue	Luontainen levinneisyysalue	Uusi levinneisyysalue
25	French	B	Aire d'évaluation des risques	Aire native	Aire d'introduction
26	Georgian	B	რისკის შეფასების არეალი	ბუნებრივი არეალი	ინტროდუქციის არეალი
27	German	B, D	Risikobewertungsgebiet	Natürliches Verbreitungsgebiet	Einbringungsgebiet
28	Greek	A, E	Περιοχή αξιολόγησης κινδύνου	Εύρος κατανομής ως αυτόχθονο	Εύρος κατανομής ως αλλόχθονο
29	Hebrew	A	אזור הערכת סיכונים	תחום תפוצה טבעי	תחום פלישה
30	Hindi	A	जोखिम आकलन क्षेत्र	देशी रेंज	प्रवेशित रेंज
31	Hungarian	B, E	Kockázatértékelés célterülete	Őshonos elterjedési terület	Nem őshonos elterjedési terület
32	Icelandic	B, D	Áhættumatssvæði	Upprunalegt útbreiðslusvæði	Ílent útbreiðslusvæði
33	Indonesian	B	Wilayah penilaian risiko	Wilayah asal	Wilayah yang diperkenalkan
34	Italian	C, D	Area di valutazione del rischio	Distribuzione nativa	Area di introduzione
35	Japanese	B	リスクアセスメント地域	自然生息域	導入域
36	Kazakh	B	Тәуекел бағалау аймағы	Жергілікті аумақ	Енгізілген аумақ
37	Khmer	A	តំបន់វាយតម្លៃហានិភ័យ	ពូជមួយស្ថិតនៅមានក្នុងតំបន់	ពូជថ្មីដែលបានដាក់បញ្ចូល
38	Korean	B	위험평가 지역	토착 범위	도입 범위
39	Kyrgyz	B	Тобокелдиктерди баалоо аймагы	Жергиликтүү аймак	Киргизилген аймак
40	Lao	A	ພື້ນທີ່ການປະເມີນຄວາມສ່ຽງ	ຊ່ວງພື້ນເມືອງ	ຊ່ວງແນະນຳ
41	Latvian	A	Riska novērtējuma zona	Dabiskais areāls	Introdukcijas areāls
42	Lithuanian	A	Rizikos vertinimo teritorija	Natūralus arealas	Dirbtinis arealas
43	Macedonian	A	Подрачје за проценка на ризик	Природен ареал	Ареал на интродукција
44	Malay	A	Kawasan penilaian risiko	Lingkungan asal	Lingkungan diperkenal
45	Mongolian	C	Эрсдэлийн үнэлгээний талбай	Нутагшсан газар	Угуул нутаг
46	Montenegrin (Latin)	A, D	Područje procjene rizika	Prirodni areal rasprostranjenja	Areal rasprostranjenja van prirodnog
46	Montenegrin (Cyrillic)	A, D	Подручје процјене ризика	Природни ареал распрострањења	Ареал распрострањења ван природног

Table 5. (continued).

ID	Language	Case(s)	Risk assessment area	Native range	Introduced range
47	Nepali	B	जोखिम मूल्याङ्कन क्षेत्र	रैथाने क्षेत्र	रैथाने भन्दा बाहिरको क्षेत्र
48	Norwegian	B	Området som omfattes av risikovurderingen	Naturlig utbredelsesområde	Den introduserte artens utbredelsesområde
49	Pashto	A	د خطر ارزوني سیمه	بومي ساحه	معرفي شوي ساحه
50	Persian	A	منطقه ارزیابی خطر	گستره بومی	گستره معرفی شده
51	Polish	A	Obszar oceny ryzyka	Zasięg rodzimy	Zasięg introdukowania
52	Portuguese	C, D	Área da avaliação de risco	Distribuição nativa	Área de introdução
53	Romanian	A	Zona de evaluare a riscului	Regiune nativă	Regiune de introducere
54	Russian	A	Регион оценки риска	Естественный ареал	Приобретенный ареал
55	Serbian (Latin)	A, D	Područje procene rizika	Originalni areal rasprostranjenja	Rasprostranjenje izvan originalnog areala
55	Serbian (Cyrillic)	A, D	Подручје процене ризика	Оригинални ареал распрострањења	Распрострањење изван оригиналног ареала
56	Sinhala	A	අවදානම් ඇගැයීමේ වපසරිය	දේශීය පරාසය	හඳුන්වාදුන් පරාසය
57	Slovak	B	Vyhodnocovaná oblasť	Pôvodná oblasť	Introdukovaná oblasť
58	Slovenian	B	Območje ocene tveganja	Naravno naselitveno območje	Naseljeno območje
59	Somali	A	Qiimaynta goobaha halista	Dhir dhalad ah	Dhir aan dhalad ahayn
60	Spanish	B, D	Área de evaluación de riesgo	Área de distribución nativa	Área de distribución introducida
61	Swedish	B, D	Riskbedömningsområde	Ursprungligt utbredningsområde	Introducerat utbredningsområde
62	Tajik	A	Минтақаи баҳодиҳии хатар	Ҳудуди таҳҷои	Ҳудуди ба даст овардашуда
63	Tamil	B	இடர் மதிப்பீட்டு எல்லை	பூர்வீக எல்லை	அறிமுகப்படுத்தப்பட்ட எல்லை
64	Thai	B	พื้นที่ประเมินความเสี่ยง	พื้นที่ถิ่นกำเนิด	พื้นที่ที่นำเข้ามา
65	Tigrinya	B	ስግኣት ግምገማ ዝካየደሉ ቦታ	መበቆላዊ ቦታ	ዝተኣታተወ ቦታ
66	Turkish	B, D	Risk değerlendirme bölgesi	Doğal yayılış alanı	Giriş yapılan alan
67	Turkmen	B	Howpy bahalandyrmak çägi	Tebigy çäk	Introduksiýa edilen çägi
68	Ukrainian	A	Район оцінки ризику	Нативний ареал	Надбаний ареал
69	Urdu	A	خطرے کی تشخیص کا علاقہ	مقامی حد	تعارفی حد
70	Uzbek	A	Xavfni baholash maydoni	Tabiiy tarqalgan hududi	Introduktsiya qilingan hududi
71	Vietnamese	B	Vùng đánh giá nguy cơ	Vùng bản địa	Vùng du nhập

the framework presented here is not intended to prescribe or replace existing terminologies, but rather to provide a neutral, analytically transparent reference structure within which different linguistic traditions and policy frameworks can be compared and interpreted.

The substantially larger number of literature search results including the terms *established species* compared to *established non-native species*, and *invasive species* compared to *invasive non-native species*, underscores our preference to avoid redundancy while maintaining conciseness. As recently emphasized, usage of the term *invasive non-native species* may lead to confusion due to redundancy since all *invasive species* are inherently non-native – whereas a native species with invasive characteristics is generally referred to as a *native invader* (Carey et al. 2021). Employing the term *invasive non-native species* may therefore result in stakeholders incorrectly equating *non-native species* with invasive ones. Furthermore, many *non-native species* do not exhibit invasive characteristics (Iannone et al. 2020). Likewise, we advocate for the term *established species* unless employed within the descriptive or pedagogic context of the biological invasion process, where *established non-native species* specifically denotes the establishment phase of a *non-native species*.

The comparable number of search results for both *risk identification* and *risk screening* confirms their usage as synonyms, despite potential semantic

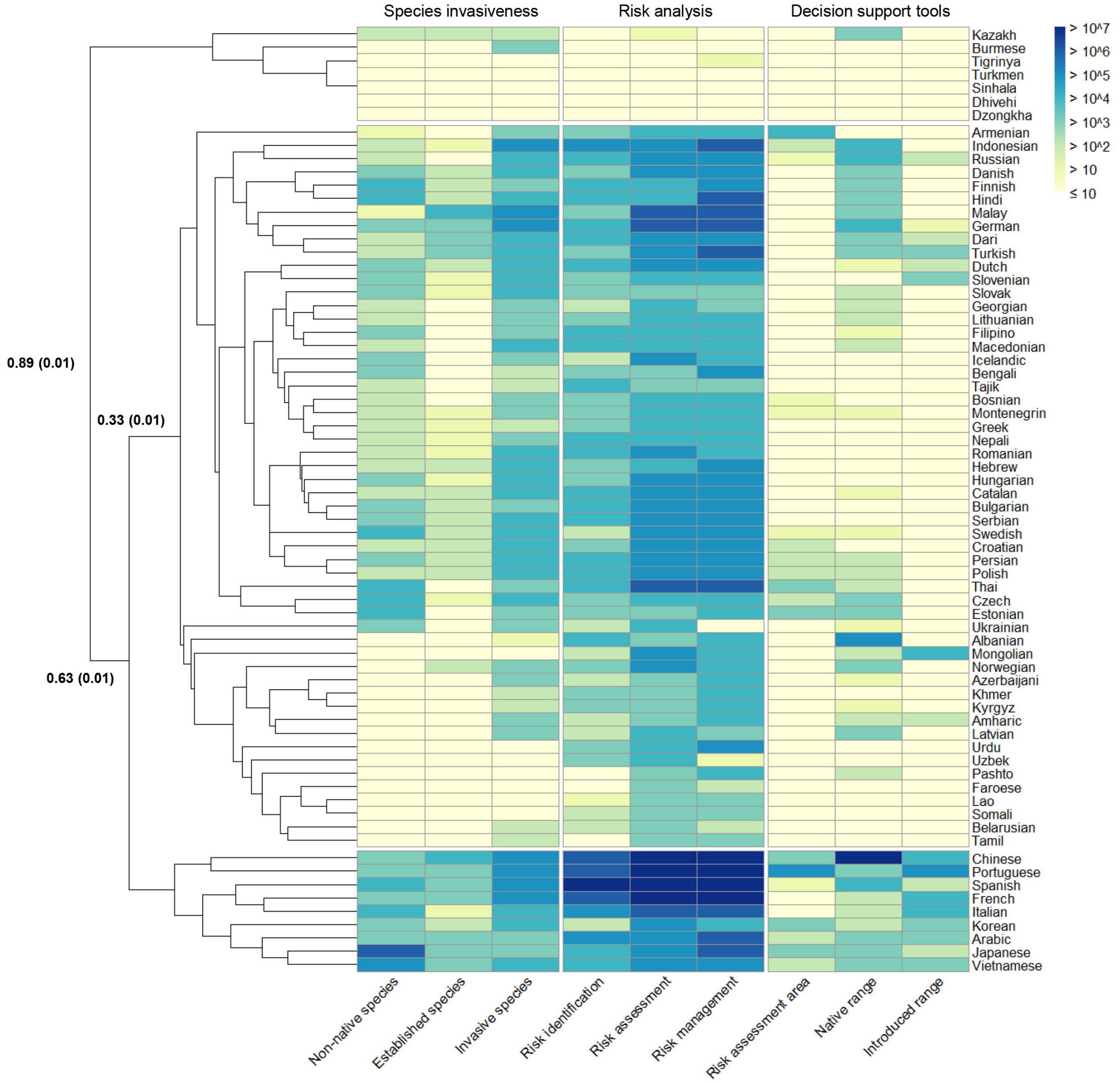

Figure 3. Combined number of search results from Google, Google Scholar and Web of Science in 70 non-English languages that, alongside English, are officially spoken across all 195 countries worldwide, for the three sets of terms in the multilingual framework (Table 2). The distance and statistical significance of the three main splits in the clusters is shown.

differences. Our preference for the former term is justified as more globally applicable for communicating risks in most languages other than English. Conversely, the prevalence of *non-native range* over *introduced range* reinforces our argument concerning the definition of both terms and underscores the necessity of minimizing obstacles in bidirectional comparisons between English and other languages (Copp et al. 2021).

The inclusion of 70 non-English languages in this study has achieved global scope, ensuring the applicability of the framework to all 195 countries worldwide. This marks a novel endeavour of its kind in invasion science, and possibly in other scientific disciplines, including the multi-level validation. Previous studies have generally relied on a subset of non-English

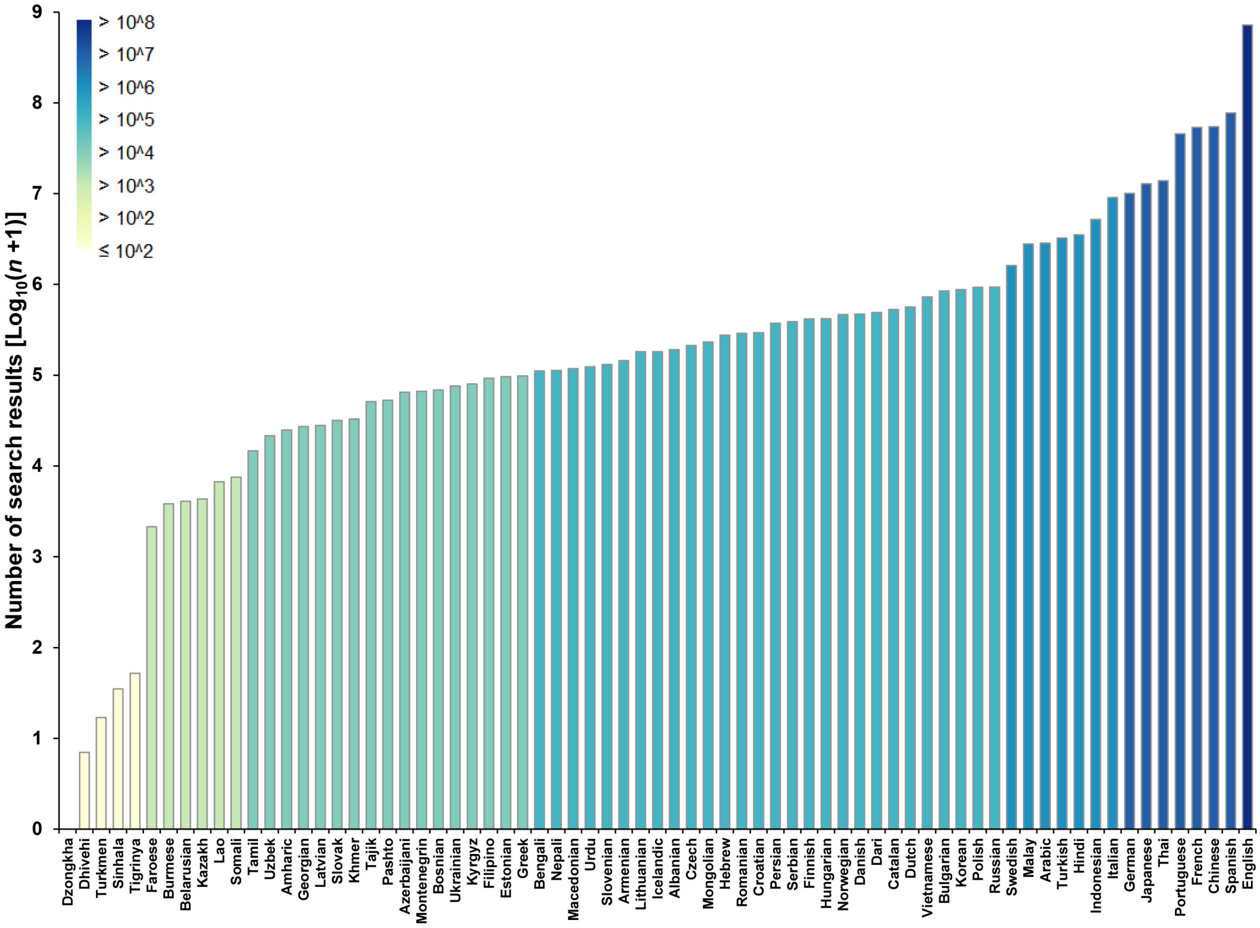

Figure 4. Ranking of the search results for the terms in the framework according to language. Ranking and grouping (across eight orders of magnitude) of the 71 languages officially spoken across all 195 countries worldwide based on the number (Log10 + 1 transformed) of Google, Google Scholar and Web of Science search results for the terms in the multilingual framework.

languages, generally included based on the authors' nationality (Angulo et al. 2021; Chowdhury et al. 2022; Soto et al. 2024). In contrast, the selection of the 30 non-English languages currently supported by the multilingual decision support tools for *risk identification* (Vilizzi et al. 2022b) stems from ongoing collaborations with invasion biologists and native speakers of the contributed languages from several countries worldwide over the past 15 years (Copp et al. 2021; Vilizzi et al. 2025a). This number of supported languages represents approximately 43% of the total number of languages included that would be required to make the toolkits globally applicable. Of note, the recent study by Soto et al. (2024) provides, as a starting point, terminology for species invasiveness (one of the three domains in invasion science identified in the present study) in 28 of the validated 70 non-English languages (see also Vilizzi et al. 2025b). These terms include *non-native species* and the somewhat more redundant *established non-native species* and *invasive non-native species*.

In certain languages, efforts were made to contribute a term translating to *non-native* that avoids *alien*, *exotic*, *foreign*, or *non-indigenous*, often diverging from current usage. In other languages, the choice to keep one of

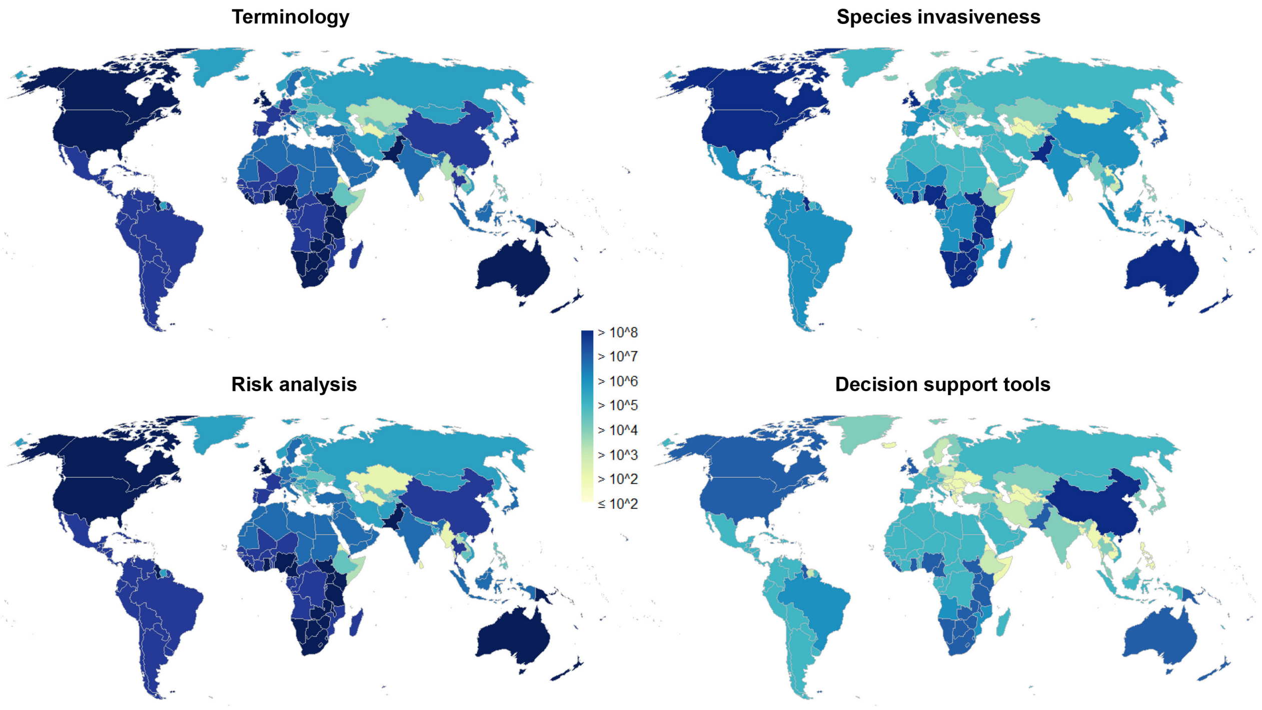

Figure 5. Ranking of the search results for the terms in the framework according to language and by country. Maps showing the world countries ranked according to the combined number of Google, Google Scholar and Web of Science search results for all terms (Terminology) and across Species Invasiveness, Risk analysis and Decision support tools. The ranking of countries with more than one official language is based on the most commonly spoken one (see Table S2).

these terms was often contextual, as they lack semantic distinction concerning *non-native species*. However, nine languages retained such terms as part of their invasion science lexicon. While this might suggest reluctance to change, it may not fully reflect the stance of all representatives from the scientific and legislative community of a certain country, as our study involved a selection of experts. Although outside the scope of this study, a broader consensus-based approach involving panels of members from academic and governmental institutions of the concerned countries could provide further insights into the adoption of equivalent terms to *non-native* in their language – even as neologisms or as part of a less commonly used lexicon. Here, this was achieved in ten languages by rendering *non-native* as the equivalent of *allochthonous*, which is a politically and culturally neutral term grounded in biology. With regard to the close-to-zero number of search results in several languages for the terms related to species invasiveness, this outcome testifies to invasion science and related terminology as a scientific discipline still in its infancy in several countries.

For risk analysis, *risk identification* not surprisingly translated as *risk screening* in the languages of Germanic origin (i.e. Danish, Faroese, German, Icelandic, Norwegian and Swedish), but also in the two Slavic languages Bulgarian and Ukrainian as well as in Turkish. In the latter two cases, this reflected the widespread usage of this term in both legislative contexts and everyday practice. With regard to the three terms pertaining to decision support tools, the differences observed in how *area* and *range* were rendered in several languages were the result of the lack of distinction between these two terms, unlike in English, but also of major semantic differences. For example, in Italian, *range* literally translates as *gamma*, which is a term used commercially to refer to a "range of products", hence inappropriate in the present context. In other languages, *range* translated as *distribution* or *distribution area*, further showing semantic differences from English.

The marked contrast in the number of search results between the terms associated with risk analysis and those related to decision support tools was clear across most languages. As previously highlighted, risk analysis stands as a firmly established scientific discipline (Heggum 2011) with standardized terminology spanning diverse fields such as medicine, economics, engineering and information technology. In this study, our focus centred on refining the definition of these terms within the realm of invasion science. Conversely, the term *risk assessment area* has gained prominence only relatively recently within this scientific discipline, primarily as part of the conceptual basis of the first-generation decision support tools for *risk identification* (Copp 2013), later formalized in the preamble of the current, second-generation decision support tools (Vilizzi et al. 2022b, 2025a). Although the term *assessment area*, common in risk analysis, along with its equivalents in other languages, would have generated a substantially higher number of search results compared to *risk assessment area*, its usage in the present context would not adequately capture the risk aspect of a species' invasion process. Despite the global usage of the decision support tools for *risk identification*, scientific publications related to them have predominantly been in English (Vilizzi et al. 2024). Apart from the tendency by non-native English scientists to publish exclusively in English, expecting that this will make their articles more visible and cited (Di Bitetti and Ferreras 2017), this trend can be attributed to the lengthy process for the official adoption of the toolkits by the concerned public authorities – a crucial part of the broader implementation of multi-level governance response options to biological invasions (Roy et al. 2024).

The provision of terms related to species invasiveness and decision support tools posed some challenges in languages where scientific terminology is still developing, unlike the well-established usage seen with the terms pertaining to risk analysis. This was evident in languages spoken in several Southeast Asian countries and underscores the necessity for the development of novel terminology. Furthermore, languages such as Bosnian, Croatian, Montenegrin, and Serbian, which are from countries that were unified under the same language before the dissolution of Yugoslavia (Greenberg 2004), displayed notable similarities. For example, the terms for *non-native species*, *established species*, *invasive species*, *risk* *analysis*, *risk identification*, *risk assessment*, and *risk assessment area* were (near-)identical across three or all of these languages. Similar patterns were noted in comparisons between Catalan and Spanish, Hindi, and Nepali, as well as Indonesian and Malay. Additionally, some similarities were seen in languages of Germanic origin (i.e. Danish, German, Norwegian) regarding certain terms related to risk analysis.

The fact that several IPBES member countries have under-represented terminology indicates that scientific output in the local language remains relatively limited. Furthermore, for countries with near-zero search results (i.e. Bhutan, Eritrea, Laos, Maldives, Pakistan, Somalia, Uzbekistan), the invasion science lexicon in the local language currently is nearly non-existent.

Conclusions

The framework provided in this study aims to set the basis for enhanced global communication about the risks of biological invasions among scientists, decision-makers and the general public (Table 1). It is built upon the well-established field of risk analysis with its three sequential components of *risk identification*, *risk assessment*, and *risk management*. These components serve as the basis for evaluating the likelihood of invasiveness of *non-native species*, and managing both *established species* and *invasive species*, using decision support tools, which themselves clear definitions of the *risk assessment area* and of the species' *native range* and *introduced range*. The strength of the proposed terms lies in their capacity to ease and enhance communication between scientists and decision-makers, to raise public awareness of the risks associated with biological invasions, and to support the successful implementation of the goals outlined both in the IPBES 2030 Agenda for Sustainable Development and in the Kunming-Montreal Global Biodiversity Framework of the Convention on Biological Diversity (IPBES 2023; Roy et al. 2024).

Frameworks in invasion science play a crucial role in ensuring clarity, consistency and comparability of research findings, thus helping informed decision-making (Roy et al. 2018; Robertson et al. 2020; Wilson et al. 2020). Different stakeholder groups (e.g. scientists, policymakers, land managers, and the public) may have varying interpretations of risk-related terms, which can influence perceptions of severity or urgency and thereby affect coordinated management efforts. Although much invasion-science research is published in English, effective biosecurity also depends on communication with local managers, policymakers, and practitioners who operate in other languages. A coherent multilingual lexicon ensures that core concepts are understood consistently across these groups, reducing ambiguity and enabling clearer risk communication and decision-making. This, in turn, will reduce fragmentation in the development and implementation of policy instruments.

We therefore advocate for the following actions (Figure 1): (1) encouraging researchers, practitioners, and relevant scientific and policy organisations to work collectively toward greater precision in terminology to resolve ambiguities – particularly in languages where the invasion-science lexicon is still developing; (2) using a multidisciplinary approach integrating invasion science principles with insights from humanistic disciplines and linguistic analysis, contextualized within the diffusion-of-English versus ecology-of-language paradigms; (3) enhancing effective communication of invasive species and associated risks through international collaboration and consensus-building efforts, including the participation of the general public in citizen-science programmes (Theobald et al. 2015) – the framework provided in this study is meant to help in these efforts; (4) expanding the currently available multilingual electronic decision support tools for *risk identification*, not only in by increasing the number of supported languages but also by incorporating the *risk assessment* and *risk management* components of the entire risk analysis process (Copp et al. 2016a; Britton et al. 2011).

As with any framework focused on terminology, its scope also defines its limitations. The present framework is designed to harmonize concepts and vocabulary across languages; it does not evaluate species-specific risks, ecological impacts, or management priorities. Its effective use therefore depends on combining it with complementary tools such as formal risk-screening protocols (cf. AS-ISK, TAS-ISK, TPS-ISK), pathway and impact assessment frameworks, and national or regional regulatory instruments. When used alongside these decision-support systems, the framework can strengthen the linguistic foundations of risk communication, improve the consistency of cross-sectoral dialogue, and support more coordinated biosecurity responses. As invasion-science terminology continues to evolve, particularly in languages where the relevant lexicon is still emerging, the framework should be viewed as a dynamic reference that will require periodic updating.

Addressing these challenges effectively requires sustained international dialogue supported by a range of global, regional and thematic cooperation mechanisms. Key global and international policy and science forums that facilitate such dialogue include the Convention on Biological Diversity (CBD: https://www.cbd.int/invasive), the Food and Agriculture Organization biosecurity initiatives (FAO: https://www.fao.org), the International Maritime Organization ballast water and biofouling programmes (IMO: https://www.imo.org), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES: https://ipbes.net). Together, these global and regional platforms provide the structures needed to enhance communication, support consensus building, and advance invasion science in a rapidly changing world.

Authors' contribution

Conceptualization: L. Vilizzi, V.R.S. and M. Piria. Formal Analysis: L. Vilizzi. Investigation: L. Vilizzi, V.R.S., D.G., J.E.H., W.M.D., J.G.M., L.E. and M. Piria Methodology: L.Vilizzi and V.R.S. Supervision: L. Vilizzi and D.G. Validation: L. Vilizzi, V.R.S., D.G., J.E.H., W.M.D., J.G.M., L.E., H.S.A.E., A.I.A., E.N.M., R. Mammadov, S. Andriyono, D., M.N.A.A., A.S., B.K.S., A.A., A.V.G., D.B., O.K., V.P., D. Milošević, D.C., H.H., K.L., J.L., H.A., M.L., M. Rohtla, D.A., R. Mendoza, A.S.G., R.T.D.P., E.K., L.J.H., P.G., A.C., I.Š., J.E.J., H.T., A.B., M. Pupins, A.Š., L.P., I.J., G.H., Á.F., H.V., R.S.E.W.L., M.M., G.V., T.M., A.Y., D.P., L.M., J.C.C., M.P.C., C. Preda, D. Memedemin, R.B., S.B., K.S.Š., B.Š., L.D., P. Kristan, P.S., R.D., R.P.D., M.J., K.H.O., K.A.T.T., T.D.B., B. Yoğurtçuoğlu, S. Ağdamar, B. Yuldashov, P. Khydyrov, L. Vardakas, N.K., C. Perdikaris, D.L., O.B., E.U., D.D., G.L., M.G., D.U., R.Z., M. Ristovska, A.C.G., B.G., S.K., V.E.P., O.M., N.S., M.O., Y.K., V.Y., M. Arakelyan, H.K., L.M., B.J., R.P., T.G., U.A., M. Altaf, S.I., Z.A.W., S.C., M.H.H., A.O., S.D.M., J.J., M.N., F.A., H.P.S., B.B.S., V.V., S.M.G., M.A.G.K., U.P.K.E., N. Cassim, M.D.Z., R.C., K.K., N. Chan, L.M.K.K., J.D., C.D., K.I., C.S., K.S., Y.N., Y.B.T., B.W.D., C.O., Y.P., S.L., H.W., A.K., A.I. and M. Piria. Visualization: L. Vilizzi Writing – Original Draft: L.Vilizzi and V.R.S. Review & Editing: L. Vilizzi, V.R.S., D.G., J.E.H., W.M.D., J.G.M., L.E., H.S.A.E., A.I.A., E.N.M., R. Mammadov, S. Andriyono, D., M.N.A.A., A.S., B.K.S., A.A., A.V.G., D.B., O.K., V.P., D. Milošević, D.C., H.H., K.L., J.L., H.A., M.L., M. Rohtla, D.A., R. Mendoza, A.S.G., R.T.D.P., E.K., L.J.H., P.G., A.C., I.Š., J.E.J., H.T., A.B., M. Pupins, A.Š., L.P., I.J., G.H., Á.F., H.V., R.S.E.W.L., M.M., G.V., T.M., A.Y., D.P., L.M., J.C.C., M.P.C., C. Preda, D. Memedemin, R.B., S.B., K.S.Š., B.Š., L.D., P. Kristan, P.S., R.D., R.P.D., M.J., K.H.O., K.A.T.T., T.D.B., B. Yoğurtçuoğlu, S. Ağdamar, B. Yuldashov, P. Khydyrov, L. Vardakas, N.K., C. Perdikaris, D.L., O.B., E.U., D.D., G.L., M.G., D.U., R.Z., M. Ristovska, A.C.G., B.G., S.K., V.E.P., O.M., N.S., M.O., Y.K., V.Y., M. Arakelyan, H.K., L.M., B.J., R.P., T.G., U.A., M. Altaf, S.I., Z.A.W., S.C., M.H.H., A.O., S.D.M., J.J., M.N., F.A., H.P.S., B.B.S., V.V., S.M.G., M.A.G.K., U.P.K.E., N. Cassim, M.D.Z., R.C., K.K., N. Chan, L.M.K.K., J.D., C.D., K.I., C.S., K.S., Y.N., Y.B.T., B.W.D., C.O., Y.P., S.L., H.W., A.K., A.I. and M. Piria.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Number of Google, Google Scholar, and Web of Science search results and corresponding URL for five terms used in invasion science and adopted in the framework alongside their alternative terms across three domains (Species invasiveness, Risk analysis, Decision support tools).

Table S2. List of the 195 world countries with their respective 71 language(s) (ordered by percentage of population speaking in case of more than one language) in which the terms in the framework were contributed.

Table S3. Details of the contributors (and authors of this study) to the terms in the framework in 70 non-English languages that, alongside English (ID = 1), are officially spoken across all 195 countries worldwide, arranged by endonym.

Table S4. Main reference documentation about legislation for non-native (invasive) species in the non-English languages comprising the terminological framework.

Table S5. Preferred (to satisfy the criteria of lexicon neutrality) and most common term (both in the singular voice) used to refer to *non-native species* in the 70 non-English languages that, alongside English (ID = 1), are officially spoken across all 195 countries worldwide, making up the terminological framework.

Table S6. Total number of search results from Google, Google Scholar, and Web of Science for each of the three sets of terms in 71 languages officially spoken across all 195 countries worldwide.

http://www.reabic.net/journals/mbi/2026/Supplements/MBI_2026_Vilizzi_etal_SupplementaryTables.pdf

Figure S1. Heat map showing the validity for all nine terms in the 70 non-English languages that, alongside English, are officially spoken across all 195 countries worldwide, making up the terminological framework based on ChatGPT output responses.

Figure S2. Ranking based on ChatGPT output responses for the 70 non-English languages that, alongside English, are officially spoken across all 195 countries worldwide and make up the terminological framework.

Figure S3. Ranking based on ChatGPT output responses of the nine terms in the terminological framework in 70 non-English languages that, alongside English, are officially spoken across all 195 countries worldwide.

Figure S4. Map showing the countries for which the decision support tools for risk identification (Aquatic Species Invasiveness Screening Kit; Terrestrial Animal Species Invasiveness Screening Kit; Terrestrial Plant Species Invasiveness Screening Kit) are currently applicable in the respective language and not yet applicable (turquoise).

Figure S5. Members and observers of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), with the member countries (turquoise) having under-represented terminology.

http://www.reabic.net/journals/mbi/2026/Supplements/MBI_2026_Vilizzi_etal_SupplementaryFigures.pdf

Appendix 1. Inclusion of languages. Validation. Second-step validation – AI querying.

http://www.reabic.net/journals/mbi/2026/Supplements/MBI_2026_Vilizzi_etal_Appendix_1.pdf

Appendix 2. Reports from ChatGPT for validation of the terms in the framework at the scientific, academic, policymaker and ecological levels in in 70 non-English languages that, alongside English, are officially spoken across all 195 countries worldwide.

http://www.reabic.net/journals/mbi/2026/Supplements/MBI_2026_Vilizzi_etal_Appendix_2.xlsx

Appendix 3. Ratio between the number of Google search results from the first author's search and that from the experts' search of the terms in the framework in each of 70 non-English languages that, alongside English, are officially spoken across all 195 countries worldwide.

http://www.reabic.net/journals/mbi/2026/Supplements/MBI_2026_Vilizzi_etal_Appendix_3.xlsx

Appendix 4. Number of search results from Google, Google Scholar and Web of Science and respective URL for each term in the framework in 70 non-English languages that, alongside English, are officially spoken across all 195 countries worldwide.

http://www.reabic.net/journals/mbi/2026/Supplements/MBI_2026_Vilizzi_etal_Appendix_4.xlsx

Appendix 5. Number of search results from Google, Google Scholar and Web of Science and respective URL for the preferred and most common term for non-native species in the 70 non-English languages that, alongside English (ID = 1), are officially spoken across all 195 countries worldwide, making up the terminological framework.

http://www.reabic.net/journals/mbi/2026/Supplements/MBI_2026_Vilizzi_etal_Appendix_5.xlsx