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**Conference of the Parties to the Convention on Biological Diversity**
**Sixteenth meeting**
Cali, Colombia, 21 October–1 November 2024
Item 21 of the provisional agenda*
**Invasive alien species**

# Progress on requests to the Executive Secretary from decision 15/27 on invasive alien species**

**Note by the Secretariat**

## I. Introduction

1. In paragraph 12 of decision 15/27[1] on invasive alien species, the Conference of the Parties to the Convention on Biological Diversity made a number of requests to the Secretariat to undertake in collaboration with the Inter-Agency Liaison Group on Invasive Alien Species. During the current intersessional period, the Inter-Agency Liaison Group held three meetings (2 online and 1 face-to-face) during which the members discussed and advanced on the work requested by the Conference of the Parties.

2. Progress on some of these activities was presented to the Subsidiary Body on Scientific technical and Techological Advice at its twenty fifth meeting.[2] The purpose of this document is therefore to complement that information and present the progress on the requests made by the Conference of the Parties to the Inter-Agency Liaison Group on Invasive Alien Species since the twenty-fifth meeting of the Subsidiary Body.

## II. Progress on activities undertaken in response to paragraph 12 of decision 15/27

### A. Proposal to the Economic and Social Council's Sub-Committee of Experts on the Transport of Dangerous Goods.[3]

3. The Conference of the Parties requested the Secretariat to prepare a draft proposal to the Economic and Social Council's Sub-Committee of Experts on the Transport of Dangerous Goods on a globally harmonized labelling system. A proposal was developed with support of the Inter-Agency

* CBD/COP/16/1.
** The present document is being issued without formal editing.
[1] Decision 15/27.
[2] CBD/SBSTTA/REC/25/6.
[3] This proposal was developed with financial support from the European Union.

Liaison Group. The Secretariat submitted the proposal[4] for consideration of the the Sub-Committee of Experts on the Transport of Dangerous Goods at its 64th meeting which was held in Geneva from the 24 june to 3 July 2024.

4. Representatives from the Secretariat attended the 64th meeting of the the Sub-Committee of Experts on the Transport of Dangerous Goods to present the proposal. During the meeting, some experts acknowledged the existing risks of invasive alien species as environmentally hazardous living organisms and highlighted the regional character of the issue. They considered that the Sub-Committee might not be the ideal body to address this problem, in particular due to the difficulties in labeling an species as invasive when it depends on the context and where they may be introduced. The experts indicated that the proposal can therefore be better addressed at national or regional level through other regional forums or trade conventions. Some experts raised concerns about the challenges in the harmonisation of the proper classification of such species, as such criteria could vary largely among the different regions in the world.The final report of this meeting can be found here.[5]

## B. Collaboration with the International Plant Protection Convention

5. The Conference of the Parties requested the Secretariat to continuing collaboration with the International Plant Protection Convention (IPPC) towards developing a globally harmonized and operational voluntary guidance on the cleanliness of sea containers and their cargos. In this respect, the Secretariat has engaged on a series of discussions and activities with IPPC to support their process of development guidance for sea containers. Among these activities are the participation on a workshop to explain the importance of this work for the Convention on Biological Diversity, as well as attending the eighteenth meeting of the Commision on Phytosanitary Measures (CPM), in April 2024.[6]

6. During the thirteenth meeting of the Inter-Agency Liaison Group, a representative of the IPPC informed the members that the CPM has actively considered the subject of pest spread through contamination of sea containers since 2008, and that as a result, in 2015, CPM Recommendation 6 on Sea Containers was adopted. Later a Focus Group was established, and the outcomes of its work were presented to CPM 18, where the revised CPM Recommendation 6 was adopted,[7] with CPM-18 also agreeing to extend the mandate of the Focus Group until 2027, with new terms of reference to continue its work towards identifying effective and viable options for pest risk management, including assessment of the uptake and impact of the revised CPM Recommendation 6.

7. In parallel, the IPPC Secretariat will work with the Convention on Biological Diversity towards considering renewing the joint workplan of the two organizations, taking into account Target 6 of the Global Biodiversity Framework. The importance to minimize the risk of duplicate or conflicting measures and advice was noted by the IPPC, as well as the fact that existing IPPC guidance material, available on the IPPC website, in addition to experiences and insights gained through the continued work of the Focus Group ,will provide significant support in activities related to the work of the Convention on Biological Diversity and the Inter-Agency Liaison Group.

## C. Determining how approaches for the prevention, control and management of invasive alien species may be usefully applied to biological invasions of pathogenic agents

8. The Conference of the Parties requested the Secretariat to continue collaboration with members of the Inter-Agency Liaison Group with a view to determining how approaches for the prevention,

[4] ST/SG/AC/.10/C.3/2024/2 Considering invasive alien species as environmental hazardous living organisms https://unece.org/sites/default/files/2024-03/ST-SG-AC10-C3-2024-02E.pdf

[5] ST/SG/AC.10/C.3/128 - Report of the Sub-Committee of Experts on the Transport of Dangerous Goods on its sixty-fourth session.

[6] ST/SG/AC.10/C.3/2024/2 Considering invasive alien species as environmental hazardous living organisms. This activity was carried out with financial support from the Europeean Union.

[7] CPM Recommendation on Sea Containers https://www.ippc.int/en/publications/84233/.

control and management of invasive alien species may be usefully applied to biological invasions of pathogenic agents, in particular zoonotic pathogens; as well as to collaborate in identifying gaps in knowledge, monitoring, and management of emerging infectious diseases affecting biodiversity and human health that relate to or are facilitated by invasive alien species, and to propose measures for mitigating and minimizing the negative effects on biodiversity and human health and preventing the further introduction and spread of relevant invasive alien species.

9. In response to this request, the Secretariat partnered with the International Union for the Conservation of Nature (a member of the Inter-Agency Liaison Group) to develop a study[8] on this topic. The study was then presented to the Inter-Agency Liaison Group and was finalized in collaboration with the group. The study is presented in annex I to the present document.

## D. Update of the toolkit on invasive alien species and development of training materials

10. The Conference of the Parties also requested the Secretariat in collaboration with the Inter-Agency Liaison Group to develop advice on the evaluation of existing capacity and needs for monitoring, preventing and controlling the introduction and spread of invasive alien species and thereafter as relevant, update the online toolkit on invasive alien species and develop additional training materials.

11. In response to the above, the Inter-Agency Liaison Group undertook a stocktaking exercise to review available international guidance as well as a revision of the results and recommendations of the Thematic Assessment of Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and ecosystem services[9], with a view to identifying information that could be useful to support Parties in implementing Target 6.

12. Using the information from the stocktaking, an updated version of the online toolkit[10] on invasive alien species was developed by the Inter-Agency Liaison Group under the leadership of CBD Secretariat and the International Union for the Conservation of Nature. The toolkit provides a brief overview of invasive alien species and Target 6 and presents key voluntary actions that can be taken towards the implementation of the target. The toolkit is available in annex II to the present document.

13. In addition to the toolkit, awareness raising and training materials[11] were also developed on topics such as management of priority species and pathways of introduction, identification and management of priority areas, as well as the application of international data standards in national and regional databases containing information on invasive alien species. The training materials are available in annex III to the present document.

[8] This study was developed with financial support from Japan Biodiversity Fund.

[9] Helen E. Roy and others, *The Thematic Assessment Report on Invasive Alien Species and their Control: Summary for Policymakers* (Bonn, Germany, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services Secretariat, 2023).

[10] The toolkit has been developed with financial support from the Japan Biodiversity Fund and the European Union.

[11] Developed with financial support from Japan Biodiversity Fund and the European Union.

# Annex I

## Study on how approaches for the prevention, control and management of invasive alien species may be usefully applied to biological invasions of pathogenic agents, in particular zoonotic pathogens

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The present document was developed with the generous support from the Japan Biodiversity Fund

# I. Purpose

1. This study has been developed in response to the request made by the Conference of the Parties to the Convention of Biological Diversity (CBD) to the Executive Secretary through decision 15/27, to collaborate with members of the Inter-Agency Liaison Group on invasive alien species to determining how approaches for the prevention, control and management of invasive alien species (IAS) may be usefully applied to biological invasions of pathogenic agents, in particular zoonotic pathogens.

2. Based on the above, the purpose of this study is to improve the understanding of the IAS and pathogenic agents' nexus, the impacts of IAS related pathogens on both wildlife and human health, and to help with the identification of management measures to prevent and reduce these impacts. The scope of the document is not limited to zoonosis, and considers animal and plants pathogens, as long as they are considered alien to the affected area or are spread by a species (as a host or vector) which is alien within the affected area.

3. An improved understanding of the complex IAS and pathogen relationship at the human-wildlife-environmental interface will further highlight the potential for long-term benefits to both biodiversity and human health that could be achieved by addressing biological invasions of IAS, in line with the One Health approach.

4. The study will cover the following aspects:

(i) the linkages between IAS and pathogenic agents,

(ii) gaps in knowledge, monitoring, and management of emerging infectious diseases affecting biodiversity and human health that relate to or are facilitated by IAS, and

(iii) proposed measures for mitigating and minimizing the negative effects of pathogenic agents on biodiversity and human health and preventing the further introduction and spread of relevant IAS;

(iv) identification of relevant tools and resources that could be of use to stakeholders.

# II. Overview of pathogens spread by invasive alien species and invasive alien species acting as pathogenic agents

5. Invasive Alien Species are considered one of the main drivers of biodiversity loss (Brondizio *et al*. 2019). Disease transmission and parasitism are among the key mechanisms of impact recognized within the IUCN Environmental Impact Classification for Alien Taxa (EICAT) scheme (IUCN 2020). IAS can act as pathogens themselves or as vector/host/reservoir of pathogens. In addition, IAS may facilitate the spread of pathogens by modifying/improving the ecological conditions for transmission to native wildlife and humans. This was already identified by Elton (1958), who described a few examples of the impact on both wildlife health and human health caused by the spread of pathogens[12] and diseases by IAS, as well as by IAS acting as pathogens themselves. Since then, the body of scientific literature on the topic has grown substantially.

6. The recent landmark assessment on invasive alien species and their control by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2023) has synthesized the available information on the influence of IAS on pathogen dynamics in invaded ranges, as well as IAS acting as pathogens (they are usually included in a broader category, named "microbes"[13]), and the relevant impacts on nature, on nature's contributions to people, and on good quality of life. The IPBES report documented how IAS impacts on human health may vary from

[12] A pathogen is defined by the Cambridge dictionary as "any small organism, such as a virus or a bacterium that can cause disease" https://dictionary.cambridge.org/dictionary/english/pathogen

[13] Note that this is a very heterogenous category in IPBES where it is not possible to discriminate pathogens from other "microorganisms" (Sven Bacher, in litt. 2024)

nuisance to poisoning, disease and death, for example through zoonotic diseases transmitted by invasive mosquitos, which may inflict misery, chronic disease and death (Bacher *et al.* 2023).

7. IAS - encompassing all taxonomic groups (including domesticated animals and cultivated plants that have established beyond captivity or cultivation) and across all habitats - may contribute to the spread of pathogens by interacting in different ways and different combinations with other native or alien species (Scalera 2022), by falling into multiple, broad and partly overlapping categories, such as:

- **IAS acting as pathogens** – an infectious pathogen (microbe or parasite) that is not native to a country or region.[14] "Alien" pathogens may be difficult to identify, because of the inherent difficulties of recognizing their alien vs. native status (specifically when it comes to understanding their origin) and may, of course, be spread by either a native or alien host.
- **IAS acting as reservoirs** – a population of an IAS that is a natural carrier (or "habitat") of a pathogen that may serve as a source of the pathogen for other species (which may be either native or alien) before it is transmitted to a potential host (which may be either native or alien), presenting a risk to native wildlife or human health. The reservoir IAS may, or may not be affected by the pathogen, and the pathogen may or may not be native to the country or region. However, a pathogen in a IAS introduced to a new location may not be able to transmit in case of lack of suitable vector.[15]
- **IAS acting as vectors** – a population of an IAS that is a vector of a pathogen, i.e. it transmits the pathogen (from a reservoir, which may be either alien or native) to a host. The vector may carry a pathogen agent through purely mechanical means or may support growth or changes in the pathogen, required prior to transmission of a pathogen to a host[4]. The vector is not affected by the pathogen, and the pathogen may or may not be native to the country or region.
- **IAS acting as hosts** – a population of IAS that is affected by a pathogen and may or may not present a risk to native wildlife or human health, e.g. it may have limited ability to transmit (dies quickly due to infection) or doesn't transmit (dead-end host).
- **IAS acting as facilitators** – a population of an IAS helping the occurrence of a pathogenic agent by increasing or changing the overall habitat/ecosystem suitability for the relevant species acting as host/vector/reservoir. E.g. IAS may change ecosystem interactions and provide increased opportunities for spillover to a human or wild animal hosts.

[14] To be noted that the terminology used here is taken from the technical jargon used in invasion ecology. It is recognized that the interpretation of terms and concepts may largely differ between the different disciplines involved in this highly transversal topic, e.g. in veterinary science, epidemiology, etc. For example, an alien pathogen may be "endemic" in the epidemiological sense, but not in ecological terms, as this would not be consistent with the definition of alien (i.e. an "endemic" species would be also native). This is an issue to be addressed as part of the challenges of promoting cross-disciplinary approaches and coordinating efforts to optimize synergies between different fields.

[15] https://archive.cdc.gov/www_cdc_gov/csels/dsepd/ss1978/lesson1/section10.html

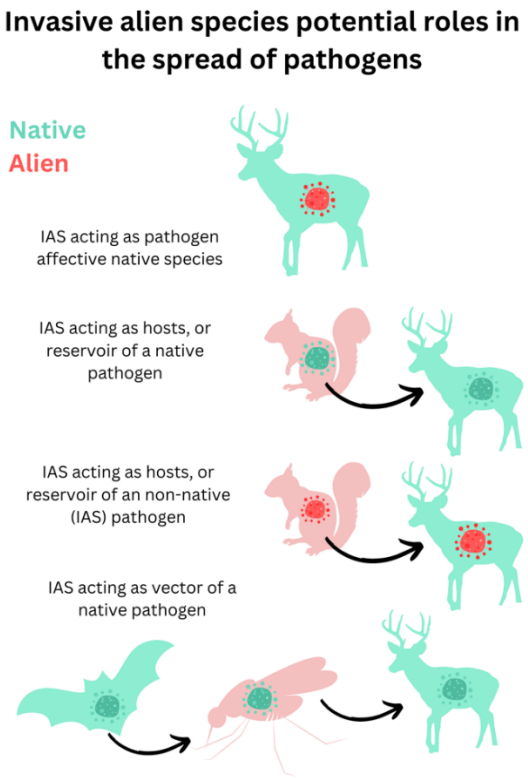


Figure 1 **Role of invasive alien species in the spread of pathogens**

8. In terms of direct impacts, IAS acting as pathogens and pathogens spread by IAS (here after referred to as "IAS-related pathogens") represent a major threat to biodiversity and wildlife health, as well as to human health directly (i.e. transmission of zoonotic diseases, that can lead to epidemics). Of those actual or potential IAS-related pathogens the following are covered by the present document:

- **IAS threatening health of native species of wild fauna and flora**
- **IAS threatening human health**

9. IAS-related pathogens may interact with the other species occurring in the ecosystem by affecting the outcomes of biological invasions themselves. In addition to threatening wildlife health and human health, IAS acting as pathogens and IAS-related pathogens may directly or indirectly threaten also human wellbeing; food security and the economy, e.g. disrupting cropping systems and livestock production; biodiversity and ecosystem services, e.g. via landscape degradation or habitat loss; or the livelihoods of Indigenous Peoples and local communities. Bacher *et al*. (2023) further outline documented impacts of IAS and IAS-related pathogen on nature's contributions to people via provision of food and feed, by provoking significant crop losses and decrease in forest tree production. For example, globally, annual crop losses to plant pests are estimated to be between 20 to 40 percent of production. In terms of economic value, plant diseases alone cost the global economy around US$220 billion annually (Agrios, 2005) and invasive insects around US$70 billion (Bradshaw *et al*., 2016). However, these cases are not directly covered by this study because, despite the clear link to wildlife and human health impacts, they are already under the focus of other policy documents and strategies.

## A. Role of invasive alien species in the introduction and spread of pathogens

10. Work in recent years have highlighted the role of IAS in the introduction and spread of pathogens and diseases (see for example Roy *et al*. 2017, Stoett *et al*. 2019, Chinchio *et al.* 2020, Nuñez *et al.* 2020, Najberek *et al.* 2022, Zhang *et al.* 2022, Bojko *et al*. 2023a, Bezerra-Santos *et al*.

2023, Roy *et al*. 2023). However, little is known about the epidemiology of alien pathogens (including microbes and parasites) in association with vectors and wildlife hosts, therefore assessing the risk of entry, establishment and spread of IAS related pathogens is very difficult (Roy *et al*. 2017). The introduction of alien species represents a potential driver of change in pathogen ecology and distribution (Chinchio *et al*. 2020). Further, given the paucity of data on the links among IAS-related pathogens, their relevant vectors and hosts causing zoonotic diseases, the magnitude of risks and impacts arising from invasive pathogens on human health are difficult to discern (Hulme 2014).

11. It is also important to point out that the occurrence of emerging diseases[16,17] is not always related to the movement of a pathogen into a new area. Once a pathogen is detected for the first time, distinguishing between the emergence of a known pathogen due to a change occurring to a known pathogen (e.g. viral evolution) or its new introduction, may be definitely hard, if at all possible. Nevertheless, understanding which type of emergence can be critical to informing response action.

12. The complexity and unpredictability of transmission dynamics and disease outcomes of novel host–pathogen combinations linked to the introduction of alien pathogens (e.g. no previous coevolutionary history) are discussed through concrete examples by Roy *et al*. (2017). Similarly, Chinchio *et al*. (2020) stressed that IAS may host pathogens that are absent in the alien range but enable establishment and subsequent spillover to native species in their invaded range, possibly resulting in an increase of disease risk for humans and domestic animals and provide useful examples and case studies. Eventually, the spread of alien pathogens or pathogens spread by IAS may further facilitate the invasion process of the same or other IAS (Tompkins *et al*. 2003). Moreover, the impact of IAS-related pathogens may act in association to other key drivers of biodiversity loss – i.e. land- and sea-use change, direct exploitation of organisms, climate change, and pollution (see Brondizio *et al*. 2019) - which may further hinder the predictability of the outcomes of new IAS introductions.

13. A common situation is when a new alien species within a community may be suitable hosts for endemic pathogens and so can increase pathogen prevalence and therefore greater opportunity for transmission through "spillover"[18] to native host species, including humans (Childs *et al*. 2007, Roy *et al*. 2023, Chinchio *et al*. 2020). There are also unexpected situations such as species that are non-pathogenic in their native range, but cause diseases in their introduced range (i.e. ash fungal pathogen *Hymenoscyphus fraxineus*) (Roy *et al*. 2017). On the other hand, there are cases in which some pathogens introduced by an alien species are transmitted to a native species, and then are successively lost by the alien species during the invasion process (Solarz and Najberek 2017, Chinchio *et al*. 2020). Additionally, alien species may favor the spread of pathogens indirectly, through a facilitation process, e.g. through competitive and trophic interactions with native species or modification of local habitats, thus altering the abundance and/or contact rates among local host species, parasite infective stages, or vectors (Chinchio *et al*. 2020).

14. It is recognized that IAS have a clear negative impact when they allow a disease-causing pathogen to spread in a new area (e.g. tiger mosquito with Dengue, Zika and other pathogens), which may be less evident when they extend the host range of a native pathogen. For example, when IAS are added to the local community, the relative abundance of native species would decrease, causing

[16] Emerging diseases are defined by WHO as "diseases that appear in a population for the first time, or that may have existed previously but are rapidly increasing in incidence or geographic range". https://www.emro.who.int/health-topics/emerging-diseases/index.html

[17] According to WHOA "Emerging disease means a new occurrence in an animal of a disease, infection, or infestation, causing a significant impact on animal or public health resulting from: a change of a known pathogenic agent or its spread to a new geographical area or species; or a previously unrecognized pathogenic agent or disease diagnosed for the first time". https://www.woah.org/app/uploads/2021/06/a-emerging-disease-sop-august2022.pdf

[18] "Spillover" is the transmission of a species-specific pathogen in a novel host. In some cases, the term "spillback" is used to highlight the transmission of a pathogen from a novel host back into an origin host (e.g. from humans to animals). The concept "spillback" is similar to "reverse zoonosis" which is the spillover of a zoonotic pathogen from humans into a novel (nonhuman) host. A "secondary spillover" is also possible, in the case of transmission of a zoonotic pathogen from humans into a novel host, and then back into humans (Sparrer *et al*. 2023). However, we consider better to phase out the terms "spill back" as humans are just one species, and spillover can occur between any number of species. The "back" part suggests prior role in infection, which is often not the case.

a dilution effect via encounter reduction with a specialized pathogen (Chinchio *et al*. 2020). However, because of the greater total abundance of potential hosts on the landscape, this could potentially be offset by increases in the prevalence of generalist pathogens (Young *et al*. 2017).

## B. A focus on invasive alien species and zoonosis

15. A key review specifically dedicated at disentangling the unique contribution of IAS to zoonosis i.e. by either increasing the abundance of existing pathogens or introducing novel pathogens is the one by Zhang *et al*. (2022). This is the first comprehensive global evaluation of the relationship between IAS and zoonotic diseases, in which Zhang *et al*. (2022) assessed the role of nearly 800 established alien hosts on the over 10,000 zoonosis events across the globe since the 14$^{th}$ century, and found that the number of zoonotic disease events increase with the richness of alien zoonotic hosts (most often associated with mammals and birds), both across space and through time. Zhang *et al*. (2022) determined that at least 35.6% of established alien animals are hosts to one or more zoonoses, and that there is an average of 5.9 zoonoses per alien host (figures that may be even underestimated, given the very conservative approach used in the study). The result by Zhang *et al*. (2022) supports the hypothesis that IAS have contributed to the increased emergence of zoonoses-in recent history, e.g. over the last sixty years. They also described some examples providing striking evidence of the transmission of zoonoses by alien species.

16. A work was also made by Roy *et al*. (2023), who synthesized available information from a literature review on the role of IAS in the introduction and spread of zoonoses. They identified 272 documented interactions between IAS and zoonotic pathogens within invaded ranges, and similar to Zhang *et al*. (2022) mostly involved invasive alien mammals and birds (but other taxa were documented too). Roy *et al*. (2023) also stressed that the role of IAS in zoonotic disease transmission may exceed that of native wildlife and occur in a relatively short period following the arrival of an invasive alien species within a new region. Moreover, they noted that invasive alien populations can be more widely infected by zoonotic pathogens than sympatric native host populations (Roy *et al*. 2023). Bezerra-Santos *et al*. (2023) also provided a number of useful examples and case studies. In their review, which focused on invasive alien mammals and the risk of zoonotic parasites, Bezerra-Santos *et al*. (2023) noted that Europe has been the continent with the highest number of zoonotic parasites associated with invasive wild mammals. They also noted that zoonoses are bidirectional. The transmission of pathogens from humans to wildlife can be quite complex and problematic. For example, the hosts from spillback may be represented either by a single species or a reservoir complex composed of multiple species, some of which may actually suffer substantial morbidity and mortality or cause secondary spillover in humans (Fagre *et al*. 2022).

17. Many other works have highlighted the threats of biological invasions on human health (e.g. Hulme 2014, Mazza *et al.* 2013, Mazza and Tricarico 2018, Bojko *et al.* 2023b). The fundamental reasons why the role of IAS in the spread of zoonotic pathogens should rise concern are reported by Hulme (2014) and are equally valid when considering concerns of IAS-related pathogen impacts to native wildlife. These are summarized below:

- IAS may be more effective hosts than native species in the transmission of existing pathogens.
- IAS may facilitate the introduction of new emerging infectious diseases (EIDs) with which they have co-evolved with in their native range.
- IAS may increase the opportunity of pathogen transmission to both native wildlife and humans, as they often thrive in anthropogenic environments and may out-compete some native species.
- IAS which are known to contribute to the transmission of pathogens may continue to spread outside their native range, with climate change and other factors likely to exacerbate this spread and limiting the efficacy of response actions.
- IAS acting as new host into an established zoonotic pathogen system can amplify the impact of disease transmission to both native wildlife and humans.

### C. Relevance to emerging infectious diseases

18. The introduction of both IAS and pathogens may result in novel interactions and modify existing ones in the native communities and ecosystems (Crowl *et al.* 2008). In fact, there are evident overlaps and parallels between the fields of IAS and emerging infectious diseases (EIDs) in the processes of pathogen introduction, establishment, spread - notably the invasion curve and the relevant management response (Roy *et al.* 2017). The relation between IAS and EIDs has been discussed by several authors who also called for a greater integration and synergies between the two disciplines (see overview in Scalera 2023).

19. Biological invasions may play a key role in relation to EIDs. Many authors noted that the two branches of science (invasion science and EID epidemiology) are studying similar phenomena (see for example earlier works by Hatcher *et al.* 2012, Dunn and Hatcher 2012, Crowl *et al.* 2008, Dunn and Perkins 2012, Ogden *et al.* 2019, Nuñez *et al.* 2020) and some IAS are traditionally considered part of EIDs studies (Ogden *et al.* 2019). This may have fundamental implications for the analysis of knowledge and management gaps, as well as for the identification of appropriate response measures and possible policy follow up.

20. EIDs are a well consolidated field of research, likewise IAS. Those two concepts mobilize different sets of expertise and capacities and are characterized by their own jargon and mechanisms. Nevertheless, for the reasons expressed above, it would be fundamental for the experts from both fields to collaborate and cooperate for increased synergies in strategies and response actions (in line with the One Health approach). Moreover, because of the relevance of the issue, the risk of new EIDs due to pathogens (of alien origin or spread by IAS) needs to be addressed and minimized consistently with the tools and strategies available within the two fields. The key message would be that increasing capacity to respond to IAS will consistently and mutually benefit the health of both biodiversity and people, both technically and financially.

## III. Policy background and international governance

21. IAS may contribute substantially to change the epidemiology of pathogenic agents facilitating both transmission and spread of pathogens to native wildlife or humans. This may represent a major threat to biodiversity and ecosystem services and also affect human health by contributing to the transmission and spread of zoonotic diseases. Despite the growing body of evidence (Stoett *et al*. 2019), and regardless of the rapid escalation in biological invasions globally (Seebens *et al*. 2017), the peculiar role of IAS in the transmission dynamics of pathogens (including zoonoses) has been often overlooked or underappreciated (Bacher *et al*. 2023, Roy *et al*. 2016, Roy *et al.* 2023). IAS related pathogens have not been consistently included within the animal, plant, and human health policies.

22. However, the growing concern over the potential impact of IAS acting as pathogens themselves, as opposed to their role of IAS in contributing to the epidemiological dynamics of pathogens directly or indirectly, affecting wildlife and human health, is leading to IAS threats being increasingly recognized in the global policy context. In fact, addressing biological invasions of IAS could bring mutual benefits to mitigating the impact of pathogens and diseases to both biodiversity and human health, in line with the One Health approach. This section provides a brief overview on how the issue is being addressed at the international level by some key policy instruments.

### A. Convention on Biological Diversity

23. The Convention on Biological Diversity is an intergovernmental treaty that entered into force in 1993. It has three main objectives: the conservation of biological diversity; the sustainable use of the components of biological diversity, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

24. IAS – defined as an alien species whose introduction and/or spread threaten biological diversity[19] - have been considered by the Convention on Biological Diversity since the early days. Article 8(h) of the Convention calls to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species. So far, the Parties to the Convention have adopted twelve decisions on invasive alien species and 6 technical guidance documents have been produced on various issues related to invasive alien species. In addition, the Kunming-Montreal Global Biodiversity Framework, adopted in 2022, includes Target 6,[20] which aims to reduce the introduction of IAS and to minimize their impact.

25. More recently, in 2022 through decision 15/27,[21] the Conference of the Parties requested the Executive Secretary in collaboration with members of the Inter-Agency Liaison Group on IAS to determining how approaches for the prevention, control and management of invasive alien species may be usefully applied to biological invasions of pathogenic agents, in particular zoonotic pathogens. This shows the interest of the Parties to the Convention in understanding the complex relationship between the IAS-pathogens nexus.

26. It is worth noting that IAS are also highlighted in CBD documents related to biodiversity and human health, e.g. the WHO-CBD joint publication State of Knowledge Review on "Connecting Global Priorities: Biodiversity and Human Health",[22] and CBD/SBSTTA/REC/26/9,[23] which contains a draft global action plan on biodiversity and health interlinkages.

## B. World Organisation for Animal Health

27. The World Organisation for Animal Health[24] (WOAH) is an intergovernmental organization aimed at transparently disseminating information on animal diseases, improving animal health globally and thus build a safer, healthier and more sustainable world. As of 2024, the organization comprises 183 members and several non-members, representing most countries and territories worldwide.

28. For a safe international trade in animals and animal products, WOAH develops normative documents relating to rules that Member Countries can use to protect themselves from the introduction of diseases and pathogens, without setting up unjustified sanitary barriers. The main normative works produced by WOAH are the Terrestrial Animal Health Code,[25] the Manual of Diagnostic Tests and Vaccines for Terrestrial Animals,[26] the Aquatic Animal Health Code[27] and the Manual of Diagnostic Tests for Aquatic Animals.[28] Wild animals are included in some of these standards. WOAH standards are prepared by elected Specialist Commissions[29]and by Working Groups[30] bringing together internationally renowned scientists (including experts from the network of about 246 Collaborating Centers[31]and Reference Laboratories[32]). These standards are then adopted by the World Assembly of Delegates.[33]

29. WOAH also collects and analyses the latest scientific information on animal health and develops guidelines to support Member Countries to improve animal health. This information is made available to Countries through the WOAH website and its publications. WOAH guidelines are

[19] Decision 6/23 (footnote ii).
[20] Decision 15/4 and https://www.cbd.int/gbf/targets/6.
[21] Decision 15/27.
[22] State of Knowledge Review on "Connecting Global Priorities: Biodiversity and Human Health
[23] CBD/SBSTTA/REC/26/9
[24] https://www.woah.org/en/home/
[25] https://www.woah.org/en/standard-setting/terrestrial-code/
[26] https://www.woah.org/en/standard-setting/terrestrial-manual/
[27] https://www.woah.org/en/standard-setting/aquatic-code/
[28] https://www.woah.org/en/standard-setting/aquatic-manual/
[29] https://www.woah.org/en/about-us/key-texts/basic-texts/specialist-commissions/
[30] http://oie.jouve-si.fr/en/international-standard-setting/specialists-commissions-groups/working-groups-reports/
[31] https://www.woah.org/en/scientific-expertise/collaborating-centres/terms-of-reference/
[32] https://www.woah.org/en/scientific-expertise/reference-laboratories/terms-of-reference/
[33] https://www.woah.org/en/about-us/wo/world-assembly/

developed by internationally renowned scientists, most of whom are experts within the network of Collaborating Centers and Reference Laboratories.

30. WOAH standards, guidelines and recommendations are recognized by the World Trade Organization (on Sanitary and Phytosanitary Measures, SPS agreement)[34] as the reference documents for Countries to establish the sanitary measures necessary to protect animal life or health.

31. WOAH's mission of increased transparency on animal health situations, encompasses the health of wild animals and currently follows two reporting paths: the notification of listed diseases, and the voluntary reporting of non-listed diseases.[35] Notifications in wildlife distinguishes between free-ranging wild animals, captive wild animals and feral wild animals.

32. WOAH Members have a legal obligation to submit information to WOAH on their animal health situation in both domestic and wild animals, and a list of terrestrial and aquatic animal diseases notifiable to WOAH (WOAH listed-diseases) has been established for this purpose. The complete list of diseases for which international reporting is mandatory can be found in chapters 1.3. of the Terrestrial and Aquatic Animal Health Codes. Information on WOAH-listed diseases is reported using an online notification system: the World Animal Health Information System – WAHIS[36] (Caceres *et al*., 2017). All animal disease information reported through WAHIS is publicly available and downloadable online.

33. In addition to mandatory reporting, WOAH has established a list whose reporting is done voluntarily (WOAH non-listed diseases), to cover a further 50 or so disease groups in wildlife (with each group including one or more pathogens) deemed priority by experts, mainly for conservation purposes. Although Members are encouraged to contribute to this additional effort, they are not legally obliged to do so (Thompson *et al.*, 2024). Information on these additional diseases is reported through a separate system called WAHIS-Wild beta in 2024, available online on a separate page from the WAHIS system[37] (Thompson *et al.*, 2024).

34. In 2020, WOAH expanded its work in wildlife health and developed a strategic vision for wildlife, together with its 183 Members, over a 5-years plan (2021-2025) outlined in the Wildlife Health Framework.[38] This framework highlights the need to articulate and organise wildlife health surveillance around structural pillars which are: i) collaborations with all sectors involved in wildlife health surveillance, ii) building capacity for wildlife health surveillance and management, iii) wildlife health intelligence and data, iv) standardized guidelines and strategies, v) robust scientific knowledge and vi) awareness tools targeting diverse populations.

35. In relation to the awareness of the dangers caused by invasive alien species from a conservation, sanitary and economical point of view, in 2012 WOAH produced guidelines[39] to help Countries to assess the risk of non-native animals becoming invasive. These guidelines focus on animals as invasive species, excluding pathogens.

36. When invasive alien species are subject to trade, WOAH has also produced guidelines for risk assessment along the supply chain of wild animals. [40] Additionally, the general risk assessment on risk from wildlife diseases and to wildlife[41] can also be useful to assess the risks by IAS-related pathogens. Specific risk management strategies for people working with wild birds are also

[34] https://www.wto.org/english/tratop_e/sps_e/spsagr_e.htm
[35] https://www.woah.org/en/what-we-do/animal-health-and-welfare/wildlife-health/#ui-id-3.
[36] https://wahis.woah.org/#/home.
[37] https://www.woah.org/en/what-we-do/animal-health-and-welfare/wildlife-health/#ui-id-3.
[38] https://www.woah.org/fileadmin/Home/eng/Internationa_Standard_Setting/docs/pdf/WGWildlife/A_Wildlifehealth_conceptnote.pdf.
[39] https://www.woah.org/app/uploads/2021/03/oieguidelines-nonnativeanimals-2012.pdf .
[40] https://www.woah.org/app/uploads/2024/05/wildlife-trade-guidelines.pdf .
[41] https://www.woah.org/app/uploads/2022/04/2014-006.pdf.

available.[42] A general paper describing how WOAH can reinforce One Health strategies through a Wildlife Health Framework[43] was also published by the Organization.

### C. The International Plant Protection Convention

37. The International Plant Protection Convention (IPPC)[44] is an intergovernmental treaty established in 1951 to protect the world's plants, agricultural products and natural resources from plant pests. The IPPC is ratified by 185 contracting parties that collaborate to develop, adopt and promote the application of International Standards for Phytosanitary Measures (ISPMs)[45] as a main tool to safeguard global food security, facilitate safe trade and protect the environment. The ISPMs provide the basis for countries to develop national legislation, guidelines, and measures to protect their plant resources from harmful pests.

38. The IPPC has many common objectives with the Convention on Biological Diversity. In particular, the IPPC provides guidance on preserving biodiversity by protecting the environment from plant pests and invasive alien species – one of the main drivers of biodiversity loss.

## IV. Knowledge gaps and priority research areas

39. Several authors have highlighted the main knowledge and information gaps on IAS-related pathogens and relevant EIDs dynamics, which would deserve urgent attention, for their impact on the ability of the global health community to prevent and manage the problem with an appropriate response action (Roy *et al*. 2017, Chinchio *et al.* 2020, Fagre *et al.* 2022, Bezerra-Santos *et al*. 2023, Bacher *et al*. 2023). Roy *et al.* (2023) noted that to better understand the factors to determine the role of IAS in transmission and spillover of zoonotic diseases, ecological studies of interactions between sympatric native and invasive alien hosts, people and pathogens are needed.

40. The impact database developed within the IPBES report also revealed a clear lack of understanding and synthesis of impacts of invasive alien microbes across all regions of the world, apparently because they have been long ignored in the field of ecology (Bacher *et al.* 2023, Nuñez *et al.* 2020; Roy *et al.* 2017). It has been recognized that so far, cross-disciplinary research applied to IAS and EIDs remains relatively scanty (Nuñez *et al.* 2020). On the other hand, the development of interdisciplinary capacity, expertise, and coordination to identify and manage threats by IAS acting as pathogens or contributing to the spread of EIDs, was seen as critical to address knowledge gaps (Roy *et al.* 2017).

41. Roy *et al.* (2023) also noted that the extent to which IAS are involved in zoonotic disease transmission in changing environments, and through which mechanisms, has not been well studied (with the exception of a first analysis by Zhang *et al.* 2022). Also, Chinchio *et al.* (2020) stated that empirical research on IAS-related pathogens - needed to assess the risk of infectious disease emergence - is biased toward a selection of species and pathogens, and a global vision of IAS-associated health threats is still lacking. Bezerra-Santos *et al.* (2023) called for the need for more research on those alien mammals acting as spreaders of pathogens, raising the attention to another key problem: namely the inadequate coverage of monitoring and surveillance, especially in some areas, for either IAS and associated EIDs. Similar considerations could be extended to the other taxonomic groups.

42. In addition, while not an IAS related pathogen as per the scope of this document, the indirect role IAS play in disease transmission (including zoonosis) would benefit from more research (Roy

[42] https://www.woah.org/app/uploads/2022/08/avian-influenza-and-wildlife-risk-management-for-people-working-with-wild-birds.pdf.
[43] https://www.woah.org/fileadmin/Home/eng/Internationa_Standard_Setting/docs/pdf/WGWildlife/A_Wildlifehealth_conceptnote.pdf.
[44] https://www.ippc.int/en/.
[45] https://www.ippc.int/en/core-activities/standards-setting/ispms/.

*et al.* 2023). For example, invasive alien plant species can displace animals, that pose a risk of zoonotic disease transmission from their natural habitats into areas more frequented by people.

43. To identify knowledge gaps, research priorities, and policy recommendations with respect to alien pathogens threatening wildlife within natural and seminatural systems, Roy *et al*. (2017) carried out a collaborative horizon scanning exercise, which also allowed to prioritize such gaps. This resulted in the identification of the following 10 key areas for research and action, including those relevant to the processes of transport, introduction and establishment and spread of an alien pathogen affecting wildlife, as well as to the associated impact on native biota and ecosystems:

(a) Baseline information needed on **taxa** in source range with potential to be pathogenic to people or wildlife;

(b) Improved understanding of **pathway dynamics** and networks leading to introduction;

(c) Baseline information needed on **distribution and population dynamics** of pathogens, hosts, and vectors;

(d) Improved understanding of **life history traits** of pathogens;

(e) Need for predictive approaches to understanding **pathogen host specificity** and potential for host shift;

(f) Need for predictive approaches to understanding potential for **ecological and evolutionary adaptation** in the invaded range;

(g) Improved understanding of **transmission dynamics** in the environmental conditions in the invaded range;

(h) Baseline information needed on recipient **population, community, and ecosystem dynamics;**

(i) Improved understanding of **distribution, abundance, and population dynamics** of pathogens, vectors, and hosts in the invaded range;

(j) Improved understanding of **pathogenicity and virulence in hosts** from the invaded range.

44. Dedicated studies to assess in greater detail the priority areas relevant to IAS acting as hosts/vectors/reservoirs of pathogens would also be required, given the evident knowledge gaps (Roy *et al.* 2023).

45. Complementing the key research areas above, and addressing them through dedicated funding, would not only increase the understanding of the role of IAS in the two fields of invasion biology and epidemiology, but also enhance our capacity to appreciate the mutual benefits for both wildlife health and human health, and ultimately reduce trade-offs in line with a One Health approach.

# V. Management and monitoring gaps

46. There seems to be an underlying challenge in the fact that, when contemplating biological invasions, IAS-related pathogens are not always consistently considered, and when assessing EID risk, the role of IAS is not systematically taken into account. There are some exceptions of course, for example in Australia ("Guidelines for the Import, Movement and Keeping of Non-indigenous Vertebrates in Australia"[46] consider disease/pathogen risks, while the "Australian Veterinary Emergency Plan"[47] specifically consider feral animal control). However, monitoring and management of pathogens and IAS benefit from the systematic consideration of each other. For example, IAS incursion risk assessments should systematically consider pathogen introduction risks, and pathogen management should take into account native and invasive alien species when developing monitoring or management frameworks (including IAS that have been identified as high risk for incursion).

[46] https://pestsmart.org.au/wp-content/uploads/sites/3/2020/06/VPCGuidelinesJan14.pdf

[47] https://animalhealthaustralia.com.au//wp-content/uploads/dlm_uploads/2015/11/AUSVETPLAN_WARS_V5_.pdf

47. The analogies between IAS and EIDs regarding the ways in which they are introduced to a new region (Roy *et al.* 2017) are a useful starting point to assess management gaps and propose possible solutions and priorities for action. For example, such similarities justify for parallels in the way that introduction that IAS pathways and EIDs pathways are managed (Roy *et al.* 2017). Similarly, Ogden *et al.* (2019) explored the extent of analogies between IAS and EIDs in key concepts, processes and methodological approaches, as well as useful differences that provide opportunities for synergies, which may enhance our understanding and practical management of biological invasions and EIDs. The same concepts were reiterated by Nuñez *et al.* (2020), who stressed that similar processes affect the spread of EIDs (including zoonotic pathogens) and IAS, demonstrating the need for a common set of international management actions (e.g. from prevention via biosecurity to early detection, rapid response, eradication or containment, and mitigation) appropriate to each stage of the process (the invasion curve that equally applies to IAS and EIDs). IAS and EIDs share management insights and approaches: management goals are the same, and direct collaborations between invasion scientists, disease ecologists and epidemiologists on management and monitoring would be mutually beneficial (Ogden *et al.* 2019).

48. The main challenges to the management of the threat posed by alien pathogens and pathogens spread by IAS is linked to the unpredictable nature of invasion events and the complexity of novel host–pathogen combinations (Roy *et al.* 2017). Of course, other challenges also contribute, e.g. the failure to invest in prevention (vs. response), the interactions with climate change and other anthropogenic changes that are shifting species ranges (Schindler *et al. 2018*). However, addressing the key knowledge gaps and research priorities described in the previous section would be a first step in the right direction to create the basis for successful management of this threat. The IPBES report also recognized that the collection of documentation on the prevalence and abundance of parasites, pathogens, and vectors of human diseases associated with high-risk alien hosts would be needed to initiate effective management (Bacher *et al.* 2023).

49. Monitoring and surveillance, as well as risk analysis (encompassing hazard identification, risk assessment and risk management) are specific elements embedded in the management of IAS and EIDs, hence they may share the same constraints. For example, in relation to the role of invasive wild mammals in the introduction and spread of zoonotic parasites, Bezerra-Santos *et al.* (2023) pointed out that in those areas where this has been ignored for a long time, particularly in Africa, surveillance of invasive wild mammals is needed to better understand their impact on public health and conservation of native species. Apparently, this would have clear implications for management too (particularly in relation to IAS acting as pathogens and any other IAS with a known history of vector/host/reservoir of pathogens).

50. However, examples documenting improved outcomes in terms of prevention or control from the application of invasion science to EIDs (or the other way round, i.e. epidemiology to biological invasions) are scanty (Ogden *et al.* 2019). There are however cases that may show the mutual and correlated benefits of addressing IAS and EID, for example we can assume that biosecurity measures at borders may have public health and wildlife health benefits through prevention of biological invasions; on the other hand, spraying of insecticides in airplanes is used as a tool to reduce the risk of intercontinental spread of invasive alien mosquitos and the pathogen they carry. Nuñez et al (2020) noted that there is a need for further advancement of cross-disciplinary approaches toward applied research and management of invasive human pathogens. Also, Chinchio *et al.* (2020) noted that outside the invasion ecology field, IAS have yet to gain attention among people working in the fields of animal and public health, and the concepts explored in the ecological context cannot always find application in the development of health initiatives aimed at protecting public and animal health. For this reason, collaborations between epidemiologists and invasion scientists would need to be enabled, e.g. on joint seminars, learning exchanges, workshops and joint projects, including the development of common collaborative programs founded on common policy initiatives of national and international organizations responsible for managing EIDs and biological invasions (Ogden *et al.*

2019). This would be particularly relevant in the academic context, but also in the decision making arena, perfectly in line with the One Health approach.

51. There are no comprehensive studies with a focus on management and monitoring gaps which are affecting the implementation of appropriate response action to the threat of alien pathogens and pathogens spread by IAS. However, based on the above analogies between IAS and EIDs, it can be assumed that the same constraints for effective management identified in IPBES for IAS in general (Sankaran 2023) may be extended to the specific case of IAS-related pathogens and would be equally applicable to the constraints affecting the sound management of EIDs. They can be separated into three categories:

1) Procedural
    - Jurisdictional boundaries
    - Policy inadequacies
    - Stakeholder engagement
2) Capacity-related
    - Lack of expertise
    - Inadequate communication
    - Resourcing
3) Societal
    - Resistance to management approaches and technologies
    - Lack of awareness

# VI. Response measures

52. A dedicated, coordinated, and comprehensive set of measures to be implemented for international policy and partnerships is clearly needed to ensure coordination and interdisciplinary approaches in terms of management and research policy (Roy *et al.* 2017). As a general remark, measures targeting IAS or EID are to be intended equally valid for addressing both wildlife health and human health, as they are usually strictly interrelated. As pointed out by Nuñez *et al.* (2020) societal efforts must be directed toward managing not only the pathogens themselves, but also the environmental factors that facilitate their emergence, spread, and impacts (e.g. ecosystem alteration, wildlife exploitation, and global connectedness). In this context, fascinating opportunities for synergies between the fields of invasion science and EID epidemiology exist (Ogden *et al.* 2019).

53. The main response measures for mitigating and minimizing the negative effects of IAS acting as pathogens affecting wildlife health, and possibly preventing their further introduction and spread, are summarized by Roy *et al.* (2017). The same recommendations may be extended to encompass pathogens spread by IAS and EIDs, affecting both wildlife health and human health, as follows:

(a) Build global interdisciplinary capacity, expertise, and coordination for IAS-related pathogens, and foster the inclusion of pathogens in relevant IAS datasets, IAS risk analysis;

(b) Implement global long-term monitoring and surveillance of IAS acting as hosts and vectors, to facilitate detection and evaluation of threats;

(c) Implement global long-term health surveillance, including pathogen screening, of populations of IAS acting as hosts/vectors/reservoirs to inform pathway management;

(d) Increase awareness among policy and decision makers, wildlife managers, scientists, and citizens that IAS can present threats associated with pathogens to both native wildlife and humans;

(e) Improve representation of biological invasions within One Health initiatives, legislation, policy, and management frameworks, for how concerns IAS acting as pathogens, or IAS acting as hosts/vectors/reservoirs affecting wildlife health and human health.

54. The points above are briefly discussed in the sections below.

55. Investments in the environmental aspect of global health play a role in reducing risks and can be cost-effective. Bernstein *et al.* (2020) estimated that primary pandemic prevention actions cost less than 1/20$^{th}$ the value of lives lost each year to emerging viral zoonoses and have substantial co-benefits. Also, Dobson *et al.* (2020) assessed the economic correlated benefits of prevention measures (including for monitoring wildlife trade, reducing deforestation and greenhouse gas emissions, etc.) toward the risk of new zoonotic pandemics, and estimated that the present value of prevention costs for 10 years to be only about 2% of the costs of the SARS-CoV-2 pandemic response. Although the figures from the two studies mentioned above do not specifically refer to biological invasions, they show the importance of preventing the key drivers of biodiversity loss which may facilitate the spread of pathogens and EIDs, among which biological invasions, with their load of IAS-related pathogens, should possibly be included too. This means that it is fundamental to consider the link between IAS and EIDs, and possibly start planning the required policy initiatives for implementing the recommendations above, and assess priorities (for example, ideally the implementation of the response measures listed in point 2 and 3 above, should be based on risk assessments to prioritize resources for the relevant activities).

## A. Build capacity for early detection and rapid risk analysis

56. The need to build global interdisciplinary capacity, expertise, and coordination for IAS-related pathogens, as stressed in relation to the need to fill in the gaps in management and monitoring, is key to achieve an improved framework to address the threat of IAS and related EIDs (Roy *et al*. 2017). As noted by Ogden *et al.* (2019), the often-rapid nature of disease emergence requires quick mobilization of expertise, and resources, including funding and personnel. The urgent need to counter the impact of EIDs resulted in national and international networks of public health organizations and relevant reporting systems, which may be used as an example of similar framework for addressing the threat from IAS-related EIDs to both wildlife health and human health. Filling in the gaps in knowledge is also an essential step, and may be achieved by ensuring the systematic inclusion of pathogens in relevant IAS datasets. This, together with the mobilization of the required expertise, would further facilitate the implementation of relevant risk analysis, which are basic tools to address the threat of IAS and related EIDs.

57. This is strictly related to some specific recommendations provided in the report "Urgent Needs for Global Wildlife Health"[48] developed by EcoHealth Alliance, which focuses on four key areas where global institutions can contribute importantly by providing overarching infrastructure to support country efforts:

1) Diagnostics and investigation;
2) Reporting;
3) Planning and response; and
4) Health supportive and disease preventive development strategies.

58. Chinchio *et al.* (2020) proposed future initiatives aimed at improving our capacity for targeted actions toward the IAS most likely to threaten human and animal health, called for an increased involvement of experts in the fields of animal and human health in a new "invasion epidemiology" field. Nuñez *et al.* (2020) stressed that there is a need for further advancement of cross-disciplinary approaches toward applied research and management of invasive human pathogens, which of course is also valid for pathogens affecting wildlife. Also Machalaba *et al*. (2021) noted that despite their importance for pandemic prevention, wildlife and environmental considerations are neglected in health security priorities and plans, and provided a set of practical recommendations to improve pandemic prevention and preparedness at both the global and the national/subnational level. They also stressed that strengthening wildlife health capacity and operations should be emphasized in One Health efforts to monitor and mitigate known and novel disease risks. Calling for a first global

[48] https://www.ecohealthalliance.org/wildlife-urgent-needs.

interdisciplinary conference on the interconnections between biological invasions and epidemiology may be a way to raise the profile of the topic in the policy and academic arenas. Otherwise, the organization of a dedicated workshop focusing on the relations between IAS and EIDs and their impact on both wildlife health and human health, could be an option for paving the way to find consensus on other concrete initiatives which may be considered as a priority. Such a workshop may be organized under the umbrella of the CBD, with the objective to gather together a selected number of experts from the different relevant fields, in a first attempt to create the condition for a factual cross-disciplinary collaboration.

59. This would possibly lead to the development of dedicated networks of experts on wildlife health, human health and conservation, with experts on biological invasions and epidemiology (for plant, animal and human diseases), along with experts on pathogens, pathology, population dynamics, epidemiologic modelling, social sciences, and beyond. The objective should be to set the conditions for filling in the knowledge, management and monitoring gaps, so to contribute to the development of policy strategies, by engaging with key institutions and organizations as appropriate. This would be fully in line with the One Health initiative[49] which, according to the definition of the One Health High-Level Expert Panel (OHHLEP) "is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent" [50]. The experts may be either independent or nominated by member countries or representing organizations, depending on the relevant mandate. There are committees including experts from different disciplines working together, like the cross-jurisdictional Environment and Invasives Committee[51] (EIC) in Australia, which includes a Wildlife Health representative. However, the mandate for a dedicated network as described above should be wider, and possibly address all key knowledge and policy gaps highlighted in the documents.

60. Ideally, veterinary services in collaboration with wildlife authorities should be responsible to deal with wildlife pathogens. However, it is noted that to ensure that the roles and responsibilities are clearly allocated and distributed, the authorities competent for dealing with wildlife pathogens other than those affecting livestock, plant crops, should be identified (Roy *et al.* 2017). The identification of roles and responsibilities between all involved authorities, institutions and organizations would be fundamental to ensure the capacity building efforts are implemented on the right direction and sustainable.

## B. Monitoring and surveillance of host and vector species

61. To facilitate detection and evaluation of threats, global long-term monitoring and surveillance of host and vector species, should be developed and implemented (Roy *et al.* 2017), possibly informed by risk assessments. For this purpose, it would be necessary to identify biodiversity relevant parameters and develop the necessary monitoring schemes, to make disease surveillance in wildlife. IAS-related EIDs is too broad and too vague to be effective. The focus should be not exclusively on alien host and vector species, but also on native ones, because there could be IAS acting as pathogens and being moved through native hosts/vectors. Notably, a real challenge is that there are many native species in the wild that could be IAS in other settings, so focusing only on IAS-related EIDs, may not necessarily make it reactive from the start. It may be more important to study IAS as competent hosts for EIDs. While IAS-related EIDs surveillance would be too broad to be effective, ensuring a specific focus on IAS-related EIDs would help assessing the actual contribution of biological invasions to the epidemiological dynamics. This monitoring should contribute to the establishment or improvement of early detection and warning systems on risks of EIDs (including zoonosis).

62. Timely measures to prevent introduction and establishment of alien pathogens e.g., by implementing action in relation to relevant pathways (including through increased controls,

[49] https://onehealthinitiative.com/.
[50] https://www.who.int/groups/one-health-high-level-expert-panel.
[51] https://www.agriculture.gov.au/biosecurity-trade/pests-diseases-weeds/pest-animals-and-weeds/eic#objectives.

quarantine and health surveillance of wildlife imports, including at borders, see section below) would be more cost-effective than reactive measures to halt spread and manage disease epidemics following arrival, otherwise measures to control diseases in wildlife are generally highly constrained and eradication is rarely an option (Roy *et al.* 2017).

## C. Health surveillance of host populations

63. As a key measure to inform pathway management global long-term health surveillance, including pathogen screening, of host populations, should be implemented (Roy *et al.* 2017). Also in this case the focus should be not exclusively on alien host species, but also on native ones, because there could be IAS acting as pathogens and being moved through native hosts. To be noted that long-term surveillance does support baseline information, surveillance objectives and parameters can assist to ensure cost effective, feasible surveillance frameworks. Long-term surveillance is therefore only useful if captured somewhere in a database (see relevant discussion in section VII Tools and resources).

64. As pointed out by Ogden *et al.* (2019) methods for monitoring IAS, including active field surveillance and citizen science-based passive surveillance, have much in common with methods used to monitor risks from EIDs (including emerging zoonoses and vector-borne diseases in the environment). They include similar sampling designs are used and their implementation in target regions or sentinel sites, molecular approaches such as environmental DNA using meta-DNA barcoding are used to confirm species identities and for source attribution, exploring Earth observation data as proxies (Ogden *et al.* 2019).

65. Rapid advances in the development of systems frameworks that integrate the ecological, economic and social processes promoting spillover in rapidly changing environments will increase understanding to inform decision-making (Roy *et al.* 2023).

66. Field surveillance/monitoring is conducted for both EIDs (particularly when these are zoonoses or vector-borne) and IAS (with a focus on those IAS acting as pathogens and pathogens spread by IAS), and it may be practical and economical to develop combined field surveillance programmes: collaborative monitoring (and more systematic surveillance) for EIDs and IAS at points of entry, monitoring in field studies (including assessing indirect effects of invasions on health), and collaboration on the development and application of molecular methods for detection and demographic analysis of populations of IAS and EIDs are all areas where synergistic activities could increase efficiency (Ogden *et al.* 2019). Following invasion of a IAS, management/eradication of the IAS could include collecting specimens to investigate of IAS-related pathogens (e.g. new mosquito invasion[52], mosquitoes captured as part of eradication / management and tested for specific diseases of concern, invasive plants could be sampled to detect potential pathogens they harbor, invasive mammals surveyed for pathogens they harbor, etc.). To be considered also the need for general (passive) surveillance, which implies the diagnostic investigation of sick or dead hosts of plants and animals (wildlife).

## D. Awareness raising

67. Awareness is a key measure, and also a tool for ensuring prevention (see VII Tools and resources section below). Awareness of the role of IAS on the spread of pathogens and as pathogens themselves needs to be increased not only among policy and decision makers, but also wildlife managers, scientists, and citizens (Roy *et al.* 2017). Roy *et al.* (2023), for example, stressed the urgent need to raise awareness of the potential risks posed to human health by the transmission of zoonotic diseases by IAS. Also Chinchio *et al.* (2020) noted that is urgent to raise awareness in people working in the fields of animal and public health of the need to consider IAS as a health threat. On

[52] https://www.health.gov.au/sites/default/files/2022-12/response-guide-for-exotic-mosquito-detections-at-australian-first-points-of-entry.pdf.

the other hand, the awareness of health sector – which is a key actor – would be built through the networking activities of the "building capacity" section above.

68. Citizen science initiatives can be a great support for raising awareness among the general public or specific audiences.

69. Dedicated codes of conduct should be developed to disseminate best practice to practitioners to reduce the risk of IAS-related pathogens, along with policy briefs and articles to be delivered online through the appropriate web platforms and social media. A number of examples of such tools exists, showing that biosecurity protocols should consider all hazards, for example the Tasmanian field hygiene manual to prevent the spread of freshwater pests and pathogens.[53]

70. Another tool to raise awareness may be the development and circulation of a list of IAS which represent a threat for wildlife health and human health, similar to the "100 of the world's worst" selected by the Invasive Species Specialist Group (ISSG) of the IUCN Species Survival Commission (SSC) (Lowe *et al.* 2000), which in fact already included several species (about for one quarter of the 100 IAS listed) for which impacts are linked to wildlife and human diseases (Roy *et al.* 2017)

## E. Improve policy framework

71. The role of IAS and related EIDs require a better representation on global and regional policy and legislation framework (Roy *et al.* 2017). This should include the development of adequate management policy (e.g., banning trade of potential hosts and vectors) and research policy (e.g., funding research projects on wildlife pathogens, along with relevant risk assessments, monitoring and surveillance measures) to address the ecological and social mechanisms governing the dynamics of disease transmission (Roy *et al.* 2017, Roy *et al*. 2023). This would require assessing the risk of trade and inclusion of pathogen risks as part of these trade assessments to subsequently inform trade management/limits/bans. The development of an appropriate legal framework at the national level should also be encouraged.

72. The emergence of wildlife diseases (whether listed or not within WOAH and IPPC) should always trigger action by the concerned countries in order to prevent further spread and implement other appropriate management strategies. However, so far wildlife diseases (especially those ones spread by IAS) were not consistently included within animal, plant and human health policies (Machalaba *et al.* 2021, Roy *et al.* 2023), and as such have fallen into the gaps between regulatory bodies, which prevented any concrete and coordinated response action against emerging pathogens to be promptly undertaken (Roy *et al.* 2017, Scalera 2022).

73. For this purpose, the understanding of the socio-economic and behavioral factors that may lead to the development of improved policies on mitigating the risk of emergence and spread of IAS-related pathogens (including zoonotic agents) should be improved. This should also include the ecology and behavioral traits of those IAS which play a role in the spread of EIDs. The involvement of local communities and environmental, animal and human health stakeholders would be crucial for the preparation of any relevant policy and strategy.

74. Roy *et al*. (2017) also argued that the threats posed by alien pathogens should receive greater attention by CBD Parties through legislation, policy, and management. However, this deserves being extended to all IAS-related pathogens affecting wildlife health and human health discussed in this document, therefore requiring a coordinated approach among the various organizations that play a role on the IAS-related policy work. For this purpose, different options to address the problem may be considered, such as for instance extending the scope of the existing policy and regulations to fully consider the importance of reporting and managing any IAS-related pathogenic agents, and considering IAS and related EIDs into One Health initiatives, among others.

75. In relation to the need to extend the scope on all IAS-related pathogens and EIDs, it is worth to consider that so far the attention has largely focused on pathogens affecting human health,

[53] https://nre.tas.gov.au/invasive-species/weeds/weed-hygiene/keeping-it-clean-a-tasmanian-field-hygiene-manual.

cropping systems and livestock production (hence pathogens with a direct human medical impact or of economic importance). The spread of those alien pathogens affecting only wildlife (including both animals and plants), has received less attention despite the magnitude of their known and potential effects on biodiversity and ecosystem services (Anderson *et al.* 2004, Peeler *et al.* 2011; Fisher *et al.* 2012). Similarly, it was noted that there is a lack of comprehensive data on pathogens spread by IAS, or affecting IAS (Chinchio *et al.* 2020). Roy *et al.* (2016) explicitly called for key policies to control diseases caused by IAS to be extended to cover wild species, ecosystems and their services (hence not just humans, livestock and cultivated plants).

76. It is noted, however, that extending the scope of Member-based organization would necessarily involve ascertainment of Members, which may entail a long complex process. It would therefore be useful to start by assessing the most appropriate current and future tools that may contribute to the desired objective, taking into account the current position of the organization about IAS and related EIDs, along with its current and potential coverage in the next coming wildlife health strategy. For example, WOAH currently encourages the surveillance of wildlife health in WOAH Member Countries, (WAHIS and WAHIS-wild, ~120 Listed and emerging Diseases and 54 Wildlife Diseases), provides standards and guidelines for the surveillance of animal diseases (including notifications and sharing of data on animal diseases), a safe international trade of live animals and products of animals and the organization of the veterinary services. In the future, WOAH will have the possibility to develop and improve its activities in this area. When reporting, WOAH member countries provide information on the host(s) by indicating if the pathogen was present in animals consider feral (invasive species), wild (native species) or domestic (e.g. under human management) in the country reporting. Categorizing species according to their wild, captive or domestic status is imperative, as this would affect the response action needed. However, to avoid confusion, and in view of a greater integration between the different disciplines involved, it may be useful to ensure that terminology between the fields of biological invasions and epidemiology are better aligned.

77. Accordingly, other similar adjustments may be considered within the other related policies and relevant organizations.

78. In relation to consideration of IAS on One Health initiatives, it is worth noting that the Kunming-Montreal Global Biodiversity Framework is to be implemented taking into consideration biodiversity and health interlinkages, and the One Health Approach among other holistic approaches, therefore recognizing the value of these approach across all the areas of the framework, including addressing invasive alien species.

79. In addition, several authors argued that biological invasions should be explicitly considered within One Health approach (Roy *et al.* 2017, Ogden *et al.* 2019). The One Health approach – based on the notion that the three pillars, i.e. humans, wildlife and the environment are interrelated and that holistic approaches encompassing all three components are needed to respond to threats to human well-being – is very simple and at the same time extremely powerful in terms of understanding the connectedness between all elements involved (Ogden *et al.* 2019). The key point is that the health of humans depends on the health of the environment, and this can be ensured only by keeping healthy ecosystems. Also Roy *et al.* (2017) stressed the need for improved integrated approaches within One Health initiatives, as this would be key to understanding, detecting, and managing the emergence of alien pathogens and their impacts across borders and hosts, and inform both research and action. In this respect, and in line with the global biodiversity framework which makes a reference to other holistic approaches, the consideration of One Biosecurity[54] approach to progress invasion science and overcome the limitation of the science connections between the sectors to effectively prevent and mitigate the impacts of IAS could be important.

[54] "One Biosecurity is an interdisciplinary approach to biosecurity policy and research that builds on the interconnections between human, animal, plant, and environmental health to prevent and mitigate the impacts of invasive alien species more effectively" (Hulme 2020).

# VII. Tools and resources

80. The assumed similarities between IAS and EIDs can be of help in supporting the identification of tools and resources that can be of use for managing the threat of IAS-related pathogens affecting wildlife health and human health. In fact, approaches for management of both IAS and EIDs are similar in both fields, with the following elements being key to address this threat:

- Databases
- Predictive models
- Risk analysis
- Management options
- Ecosystem restoration

81. For example, Chinchio *et al.* (2020) suggested directing efforts at developing tools able to prioritize IAS based on the risk of transmitting pathogens with the potential to impact the health of humans, production animals, and native wildlife. Chinchio *et al.* (2020) also suggested that such tools could be based on the framework of the WOAH and IUCN for wildlife disease risk analysis and readapted to account for the main mechanisms through which IAS may affect health, in particular the introduction of new pathogens and the acquisition and spread of local ones.

## A. Databases

82. Databases, along with any other knowledge exchange platform, are a key tool for increasing harmonization and mobilization of baseline information.

83. Chinchio *et al.* (2020) recommend the gathering in *ad hoc* databases of all the available information on IAS pathogens affecting human and animal health, including their geographical distribution and prevalence in IAS populations, in both native and introduced ranges.

84. Ideally, a comprehensive (meta)database should include the following information: the pathogen, date, location, species acting as host, reservoir, vector, geographic origin, an indication of the main pathways for pathogen transmission, impact on (native) species, habitats and ecosystems, any information on zoonotic threats, etc.

85. In addition, it should be built following FAIR data principles (namely, meeting principles of findability, accessibility, interoperability, and reusability, which the FAIR acronym stands for).

86. There are currently several databases providing high-quality global data on IAS to inform nature conservation. Examples include the Global Invasive Species Database (GISD)[55], the CABI Compendium[56] and the Global Register of Introduced and Invasive Species (GRIIS)[57]. The GISD includes several comprehensive species profiles on well known pathogens such as the water mold Phytophthora spp., diseases such as West Nile virus (WNV) and pathogenic agent vectors such as Aedes spp. CABI Compendium also includes comprehensive species datasheets on pathogens, diseases and vectors and hosts. Additionally, CABI also hosts the Plant Protection Database[58] that provides access to scientific literature related to weeds, pests, and pathogens. GRIIS which presents national and sub-national annotated checklists of introduced and invasive species includes species records of diseases, pathogenic agents and their vectors and hosts.

87. Regional databases such as the European and Mediterranean Plant Protection Organization (EPPO) Global Database[59] provide pest specific data and information of interest to agriculture, forestry, and plant protection: plants (cultivated and wild) and pests (including pathogens and invasive alien plants) as well as detailed information for more than 1800 pest species that are of

[55] https://www.iucngisd.org/gisd/.
[56] https://www.cabidigitallibrary.org/product/QI.
[57] https://griis.org/.
[58] https://www.cabi.org/publishing-products/plant-protection-database/
[59] https://gd.eppo.int/

regulatory interest across Europe and the globe. Recurring zoonotic disease outbreaks such as the Bird flu and the recent SARS-CoV-2 pandemic has increased awareness and interest of emerging zoonotic diseases including the link between invasive IAS and pathogenic agents.

88. Several studies and reviews have been published in the past five years focused on the nexus between IAS and pathogenic agent, with global (Zhang *et al.* 2022), regional (Roy *et al.* 2023, Magliozzi *et al.* 2022) and national (Zhu *et al.* 2019) focus. These publications include extensive datasets with information on IAS and IAS-related pathogens (including zoonotic agents, their transmission pathways etc.) which can be considered as fundamental sources to build on what is considered a much-needed tool: an open access **global online platform** linked and interoperable with IAS databases for sharing data and information, thus creating the basis for a robust system for the prevention of IAS-related EIDs. This should aim at:

- Ensuring fast information sharing on relevant research activities and results concerning the prevention of IAS-related EID in relation to their impact on biodiversity and human health.
- Increasing the availability of the data required to support detection and monitoring of IAS and related EIDs.
- Reinforcing the coordination and the flow of information between all relevant stakeholders, e.g. health and environmental authorities, academics, researchers, and citizens.
- Increasing the understanding of how to mitigate the risks of IAS-related EIDs in relation to other drivers of biodiversity loss, allowing to fill in the current knowledge gaps and break down the existing barriers.
- Establishing better prediction and early detection systems, by improving the understanding on the root causes and underlying mechanisms linked to the spread of IAS-related EIDs.

89. It is essential that pathogens are regularly included in relevant IAS datasets, and that the relevant information is shared among all relevant audience (Roy *et al.* 2017). Overall, the GISD, GRIIS and CABI and their various compendia include valuable data on IAS as pathogenic agents, diseases, vectors etc. There are some data components that are quite specific to the management of this issue such as transmission, identification of pathogenic agents carried by vectors, outbreak alerts and emergency response protocols, that are missing or not presented in an organized way. Databases or the proposed global online platform serving this specific stakeholder group need to be complementary and maybe nested within these IAS focused information sources. To be noted also, that in principle the databases held by IUCN SSC ISSG can potentially be linked with other databases, so it may be worth to explore which other relevant resources can be actually connected, or whether it is necessary to develop a new one.

## B. Predictive models

90. Modelling is used in both fields of IAS and EIDs to clarify biological processes, predict establishment and spread, support risk assessment and assess effectiveness of interventions (Ogden *et al*. 2019, Roy *et al*. 2023). Predictive modelling, integrating biological invasion status and history into interpretation of host–pathogen networks, would be particularly useful to understand infectious disease dynamics and spillover, and anticipate the risk of invasions and EIDs, hence contributing to preventing and supporting the early warning of EIDs spread by IAS, although it would be equally applicable to any element from the continuum of management functions (Cross *et al.* 2019, Ogden *et al*. 2019, Roy *et al*. 2023).

91. Systems frameworks are being developed, that integrate the ecological, economic and social processes promoting spillover within ecosystems and policies and actors that interact with the disease systems in rapidly changing environments. It is critical to acknowledge and integrate the complex and diverse roles of IAS into such model frameworks to better understand temporal and spatial trends in health risks to underpin animal health and public health reporting (Roy *et al*. 2023).

92. A conceptual model needs to be developed encompassing interactions between global reservoirs or host and the likelihood for sharing pathogens, considering co-occurrence and phylogenetic or trait relationships, amongst native and IAS, as well as amongst different IAS (see for example Bradhurst 2021, Montgomery 2023).

## C. Risk analysis

93. Risk analysis is a key management approach for both IAS and EIDs, encompassing both risk assessment and risk management (Ogden *et al*. 2019).

94. This should include horizon scanning for EIDs (including in relation to newly arriving IAS or IAS with potential of arriving) likely to pose a threat to wildlife health and human health (see Roy *et al*. 2017).

95. Given the context dependent character of either risk analysis and horizon scanning exercises, this should be done at an appropriate geographic scale, e.g. from regional to local.

## D. Management options and financial tools

96. Management of IAS and EIDs may share the very same general approaches, from control to eradication, to containment. Of course, in both fields, prevention (encompassing biosecurity measures and quarantine), is always the first line of defense. Given the possibilities for synergies between the two fields, collaboration between experts across the range of management activities could be very advantageous (Ogden *et al*. 2019), especially for sharing information and skills, or integrating techniques so to optimize outcomes (see also Nuñez *et al*. 2020, García-Díaz *et al*. 2017).

97. According to Ogden *et al*. (2019) prevention and control programs for both EIDs and IAS share the potential for interactions with the public to be crucial for programs to succeed. Public trust and engagement (for example, in terms of personal and environmental impact, privacy/data-security, land ownership and access) may be essential for successful prevention and control.

98. Specific financial programs may be promoted to allocate resources for management and preventive actions toward IAS and EIDs.

## E. Ecosystem restoration

99. The documented link between the degradation of ecosystems, biodiversity loss and the risk of emergence and spread of diseases (including zoonotic pathogens) suggest the need to increase the attention toward the identification of tools and strategies to mitigate the spread of pathogens and diseases (along with the risk of zoonosis), by reinforcing nature protection and habitat restoration initiatives, with a clear benefit for biodiversity and ecosystem health, as well as for human health.

100. For this purpose, it would be important to address the biodiversity and health nexus with a focus on the effects of ecosystems degradation on the spread of IAS-related pathogens, in the wider context of global environmental changes. The conditions under which the protection of biodiversity and the restoration of ecosystems can contribute to mitigate the emergence and spread of pathogens, and at what scale, needs be investigated, along with the interactions with other drivers for biodiversity loss (i.e. land- and sea-use change, direct exploitation of organisms, climate change, and pollution).

101. The added value of this approach is that ecosystem restoration is also expected to improve the results of management actions and increase the resistance of ecosystems to future IAS and EIDs (see Reaser *et al*. 2021).

102. This approach requires focusing on the environment which is a crucial foundation for the health of wildlife and people. On the other hand, Zhang *et al*. (2022) found that biodiversity loss rather than native host species richness (or any natural biodiversity gradient in general) was an important predictor of zoonosis events. Land use change (e.g. the conversion of natural habitats to agricultural or urban ecosystems) has global and systematic effects on local zoonotic host communities, and as such may influence the risk and emergence of zoonotic disease in human (Gibb

*et al*. 2020). More in general, habitats under substantial human use, are characterized by greater numbers of wildlife hosts of zoonotic diseases than other undisturbed habitats (Gibb *et al*. 2020, Reaser *et al*. 2022, Roy *et al*. 2023).

103. However, large gaps were identified by Prist *et al*. (2023) in information on the effects on zoonotic diseases by restoration of native vegetation, for example composition and configuration of native habitats, or more specifically land use history and landscape structural characteristics, that are thought to affect the outcomes of restoration on disease risk, but few studies seem to consider such environmental aspects.

104. It is worth noting that the Kunming-Montreal Global Biodiversity Framework presents an opportunity for cross-sectoral action and collaboration on many areas that can lead to prevention of the spread of pathogens.

# VIII. Conclusions

105. Despite the evident contribution of biological invasions in the introduction and spread of pathogens that pose a risk to native wildlife and humans, work in silos, as opposed to through integrated, unifying approaches (e.g One Health), means that IAS are not systematically considered as part of the problem, and therefore their management is not seen as part of the solution.

106. The health of people, wildlife and ecosystems is strictly linked and interdependent, as recognized by the One Health approach. Consequently, protecting wildlife and ecosystems is acknowledged as being key to achieving One Health. However, while it is widely recognized in the relevant policy arena that key drivers of biodiversity loss - such as land use change, habitat degradation, invasive species, and illegal and poorly regulated wildlife trade, - will increase spillover risk[60], biological invasions are not yet given the deserved attention. The Kunming Montreal Global Biodiversity Framework which promotes the consideration of biodiversity and health interlinkages through its implementation, presents a great opportunity for Parties to consider IAS and health related challenges though coordinated and transdisciplinary approaches.

107. Biological invasions can be a pervasive threat in relation to the spread of pathogens, even more subtle than illegal wildlife trade itself (which is one of the key pathways for IAS). Species that are introduced in the wild outside their natural range (including through wildlife trade) and that as such are considered as "alien" may carry pathogens and contribute to their spread. As such, the introduction and spread of IAS in an ecosystem, may not only favor the transmission of new pathogens, but may also affect their dynamics within an epidemiological system. On the other hand, removing IAS, or preventing their introduction, may improve the resilience of ecosystems toward the emergence of diseases, which evidently would bring mutual and correlated benefits to both the conservation status of species, and the health of wildlife and humans. Additionally, given the limited resources available for the management of EIDs, the implementation of measures mobilised to control IAS and mitigate their impact, may create the opportunity for important positive synergies (Mahon *et al*. 2024).

108. It would be necessary to overcome siloed approaches that may prevent the One Health approach being thoroughly incorporated into current policies, i.e. by promoting synergies between different regulatory frameworks and optimize response action and resources at stake. There are existing international mechanisms that focus on managing pathogens risks to wild animals and plants, primarily under the WOAH, and IPPC. Therefore, there is an opportunity for cooperation and synergies between these organizations, the CBD who's work on IAS, which mainly focuses on IAS impacts on biological diversity, but also taking into account those on human and animal health.

109. Recognizing that alien pathogens are moved around the globe exactly like any other IAS, may have clear management implications (for example in recognizing the parallel between surveillance

[60] https://www.woah.org/fileadmin/Home/eng/Internationa_Standard_Setting/docs/pdf/WGWildlife/A_Wildlifehealth_conceptnote.pdf.

and control for IAS and pathogens) while also facilitating multi-sectoral collaboration needed for these mechanisms to more effectively address risks posed to biodiversity, as IAS acting as pathogens are often disregarded, and may fall into the gaps of existing regulations.

110. The present document offers an assessment of the gaps in knowledge and policy, with an overview of responses and tools. There is clearly a need to create synergies between the different mechanisms and tools already available for dealing with both IAS and EIDs, so that the risks posed by IAS-related pathogens are better managed. This would require that experts working on biological invasions recognize the role of IAS in relation to EIDs and familiarize themselves with the key epidemiological concepts and approaches (e.g. by systematically screening intercepted/captured IAS for pathogens) and vice-versa, that experts working in the field of epidemiology recognize the importance of IAS introductions in an ecosystem, and understand how their management can mutually benefit the prevention and mitigation of spread of pathogens and zoonosis. Such actions may help with prioritizing surveillance and control measures on IAS that pose greater health risks. However, further investigation is needed to turn the overview of options presented here into concrete initiatives that would bring tangible outcomes, depending on the level of ambition and the resources available. Supporting the development of a global cross-disciplinary network would be a first key step for ensuring the role of IAS in disease transmission is properly addressed at the appropriate scale and create consensus on priority policy measures to be undertaken. This would allow current policy and legislation gaps to be identified and addressed and ensure the implementation of holistic cross-sectoral approaches.

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Annex II

# Toolkit to support the implementation of Target 6 of the Kunming-Montreal Global Biodiversity Framework

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# 1. Introduction

## 1.1 Background

1. In response to a request made in decision XI/28[61] a toolkit to facilitate Parties to achieve Aichi Biodiversity Target 9 on invasive alien species (IAS) was produced by the Global Invasive Alien Species Information (GIASI) Partnership and the Secretariat of the Convention on Biological Diversity in 2014. The purpose of the toolkit was to provide information useful for Parties in the achievement of Aichi Biodiversity Target 9.

2. Following the adoption of the Kunming-Montreal Global Biodiversity Framework,[62] in decision 15/27[63] Parties requested the Executive Secretary to develop advice, in collaboration with the Inter-Agency Liaison Group on IAS, on the evaluation of existing capacity and needs for monitoring, preventing and controlling the introduction and spread of IAS and their harmful effects to biodiversity, taking into account relevant multilateral instruments, and thereafter as relevant, update the online toolkit on invasive alien species of the Convention on Biological Diversity (CBD). In response to this request, the CBD Secretariat and IUCN in cooperation with the Inter-Agency Liaison Group on Invasive Alien Species have produced this non-prescriptive toolkit which replaces the previous tool and provides new information in line with Target 6.

## 1.2 Purpose of the toolkit

3. The purpose of this toolkit is to provide information to assist Parties in the implementation of Target 6 of Kunming Montreal Global Biodiversity Framework.

## 1.3 How to use the toolkit

4. This toolkit should be used on voluntary basis to assist Parties, and other actors, in the implementation of actions towards Target 6 of the Kunming Montreal Global Biodiversity Framework. It provides a brief overview of IAS and Target 6 and presents the key actions that can be taken. The Enclosures to the toolkit provide a glossary of key terms, a list of resources to support the development and implementation of the actions, and information on how to develop a National Invasive Species Strategy and Action Plan (NISSAP).

# 2. Toolkit

## 2.1 Invasive alien species

### 2.1.1 What are invasive alien species?

5. An **alien species** is a species, subspecies or lower taxon, introduced outside its natural past or present distribution; this includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce.[64] An **invasive alien species** is an alien species whose introduction and/or spread threaten biological diversity.

6. Alien species are introduced to areas outside their natural range by human activities, and the mechanisms in which they are moved are termed **pathways.** These can be intentional, for example as pets or aquarium fish, or unintentional such as a stowaway in a shipping container. See Enclosure 1 for a glossary of key terms related to invasive alien species and this toolkit.

### 2.1.2 Why are invasive alien species a problem?

7. Invasive alien species are one of the major drivers of biodiversity loss, and cause dramatic, and in some cases irreversible changes to ecosystems. They have contributed solely or alongside other drivers to 60 per cent of recorded global extinctions and are the only driver in 16 per cent of

[61] Decision XI/28.
[62] Decision 15/4.
[63] Decision 15/27.
[64] Decision VI/23.

documented global extinctions. [65] Their impacts occur through different interactions, such as out-competing or predating upon native species, hybridisation, transmission of diseases, or biofouling.

8. Invasive alien species can also negatively affect economies and infrastructure across different sectors, food and water security, and human health and wellbeing. The impacts are often felt the most by communities with the greatest direct dependence upon nature, including indigenous peoples and local communities. The global economic costs of invasive alien species have quadrupled every decade since 1970, and in 2019 the annual costs of biological invasions were estimated to exceed US$423 billion.

9. The number of invasive alien species and their impacts are increasing across all regions of the Earth. Demographic, economic, and land-use and sea-use changes and their interlinkages with climate change and other drivers of biodiversity loss will continue to increase the frequency and extent of biological invasions, and the magnitude of impacts from invasive alien species.

### 2.1.3 What can be done?

10. There are effective actions that can be implemented to eliminate, minimize, reduce and or mitigate the impacts of invasive alien species on biodiversity and ecosystem services. Pathway management and border security measures can be used to prevent introductions. Early detection and rapid response capacity and capability can stop alien species that are introduced or at an early stage of invasion from becoming established and spreading. In addition, eradication, containment, and long-term control of already established invasive alien species populations can be undertaken. Such measures are more effective when an integrated governance approach is taken, including cross-sector, multi-stakeholder, and regional and international engagement. This toolkit sets out these key actions in more detail in Section 2.3. below, and also provides information on resources to support their development and implementation at a national level in Enclosure 2.

## 2.2 Invasive alien species under the Convention on Biological Diversity

### 2.2.1 CBD Article 8(h)

11. The mandate for work on invasive alien species under the CBD comes from Article 8(h)[66] of the convention text, which commits Parties to "*as far as possible and as appropriate, prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species*". In addition, decision VI/23[67] was adopted in 2002 and sets out the guiding principles for the implementation of Article 8(h). Since then, a number of COP decisions have been adopted[68] on various topics including the provision of guidance to support Parties in addressing invasive alien species.

### 2.2.2 The Kunming Montreal Global Biodiversity Framework

12. The Kunming-Montreal Global Biodiversity Framework adopted by Parties to the Convention at the fifteenth meeting of the Conference of the Parties has 23 action-oriented global targets for urgent action over the decade to 2030. Target 6 is focused on IAS,[69] and aims to *"Eliminate, minimize, reduce and or mitigate the impacts of invasive alien species on biodiversity and ecosystem services by identifying and managing pathways of the introduction of alien species, preventing the introduction and establishment of priority invasive alien species, reducing the rates of introduction and establishment of other known or potential invasive alien species by*

[65] IPBES. (2023). Summary for Policymakers of the Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H.E., *et al.* (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430692
[66] CBD Article 8. In-situ conservation.
[67] Decision .
[68] COP decisions on Invasive alien species.
[69] Target 6 https://www.cbd.int/gbf/targets/6.

*at least 50 per cent, by 2030, eradicating or controlling invasive alien species especially in priority sites, such as islands".*

13. Target 6 can be broken down into the overall aim, and three separate elements or actions (see Box 1). The first two elements aim at addressing impacts from new invasive alien species, through the management of pathways of introduction, and by preventing the introduction and establishment of invasive alien species. The types of actions that will support these elements include border security, legislation, surveillance, and early detection and rapid response. The target requires that *priority* invasive alien species are prevented from introduction and establishment, but the species classed as a 'priority' is to be determined at a national level. This could include species that are likely to have the greatest impacts upon biodiversity if they were to become established. The only quantitative aspect of the target relates to the rates of introduction and establishment for *other* (i.e. non-priority) invasive alien species, which needs to reduce by 50 per cent by 2030. To achieve these elements of the target, the pathways of introduction will need to be identified and prioritized so that resources are focused on addressing the pathways that are the most important. In addition, the quantitative aspect of the target will require an understanding of the existing or baseline rate of introductions and establishments within the country, and for surveillance and monitoring to be undertaken to identify and record new introductions and establishments.

14. The third element of the target aims to address impacts from those invasive alien species that are already established within a territory. It requires the eradication or control of invasive alien species, especially in *priority* sites such as islands. Again, the identification of which sites are a priority is to be done at a national level but could include those that are important for biodiversity and ecosystem services and vulnerable to, or are facing significant impacts from, invasive alien species. Those invasive alien species that are currently having the greatest impact or may do so in the near future (e.g. due to climate change or other drivers of change), should be prioritized for eradication. Where this is not feasible, their populations should be contained and controlled so that their impacts are mitigated.

15. Actions that can be implemented to meet the different elements of the target are outlined in Section 2.3 below, along with the baseline information and prioritisation on pathways of introduction, invasive alien species, and sites that is needed to inform these actions and track progress (see also figure I).

**Box 1. Kunming-Montreal Global Biodiversity Framework, Target 6 on invasive alien species**

The target text is presented below, broken down by colour into its overall aim, elements (actions) one of which has a quantitative aspect.

Eliminate, minimize, reduce and or mitigate the impacts of invasive alien species on biodiversity and ecosystem services by:

i. identifying and managing pathways of the introduction of alien species,

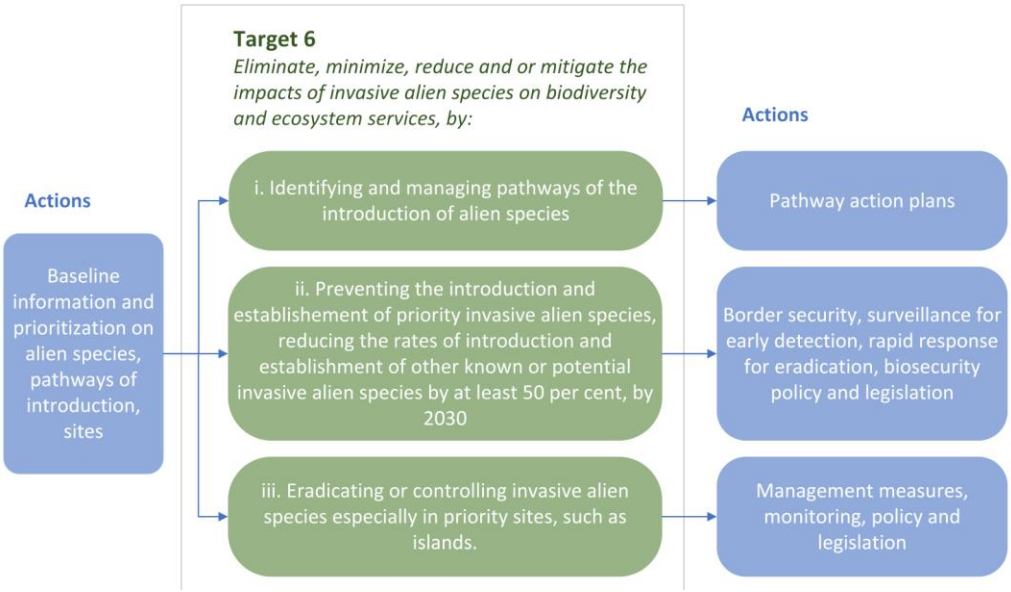
ii. preventing the introduction and establishment of priority invasive alien species, reducing the rates of introduction and establishment of other known or potential invasive alien species by at least 50 per cent, by 2030,

iii. eradicating or controlling invasive alien species especially in priority sites, such as islands.

16. The Kunming-Montreal Global Biodiversity Framework also has a set of considerations for its implementation, which are relevant when actions are taken towards the targets. Section 2.4 below provides information in the context of invasive alien species and Target 6, that can be considered when addressing these considerations of the Framework.

Figure I

**Overview of the actions that can be taken towards the different elements of Target 6**




## 2.3 Implementation of actions at a national level towards Target 6

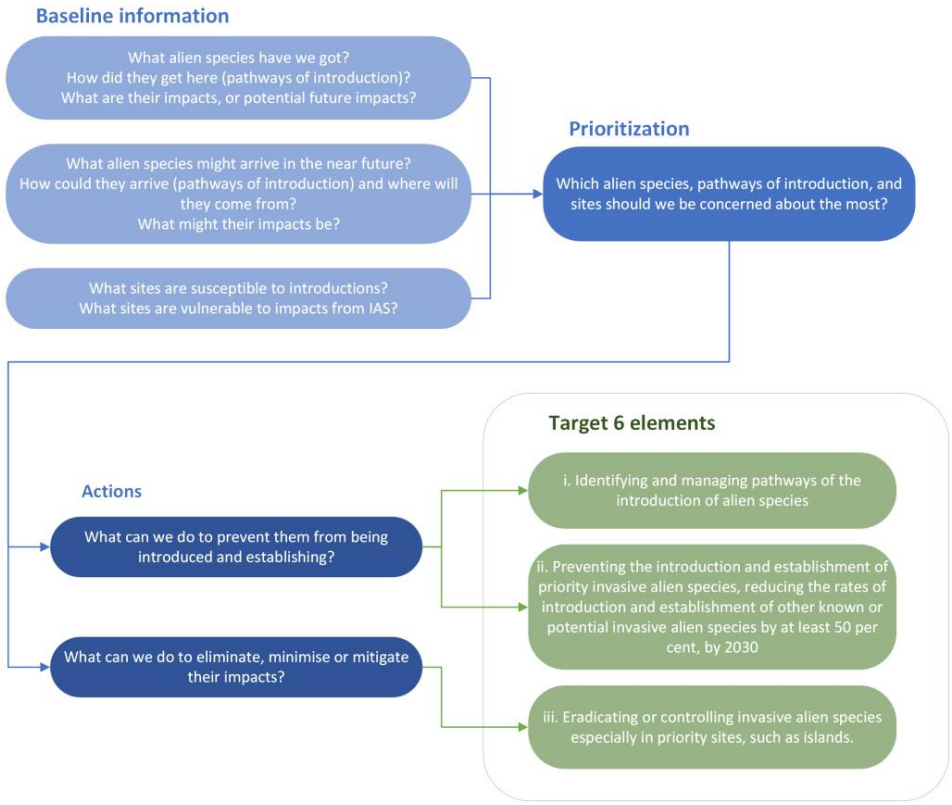
17. This section provides information useful for the development and implementation of actions at a national level to address invasive alien species for Target 6.

### 2.3.1 What do we need to know to meet Target 6

18. The series of guiding questions below can be used to help set out what essential pieces of information need to be known to produce the required baseline information in order to develop the actions needed for Target 6 (figure II).

Figure II

**What do we need to know for Target 6? The questions (in blue) can guide and inform the development of actions to address the three elements of Target 6 (in green)**




### 2.3.2 What actions can be implemented

19. The actions discussed in this section will help answer the guiding questions and are deemed to be important for successfully addressing the different elements of Target 6. The actions are grouped into four broad categories, one for baseline information and prioritisation, and one for each of the three Target 6 elements. See enclosure 2 which lists key resources that can support in the development and implementation of the actions discussed. Figure III also presents the different stages of an invasive alien species invasion over time, showing the corresponding elements of Target 6 and the actions that can be taken which are set out in this toolkit.

20. These actions are voluntary and need to be developed and implemented in accordance with national circumstances and priorities. It should be stressed that progress can be made with limited resources, and not all these actions need to be undertaken in order to see positive outcomes. As stated in the Guiding Principles for the implementation of CBD Article 8(h), preventative measures are generally more cost-effective than measures taken following the introduction and establishment of an invasive alien species.

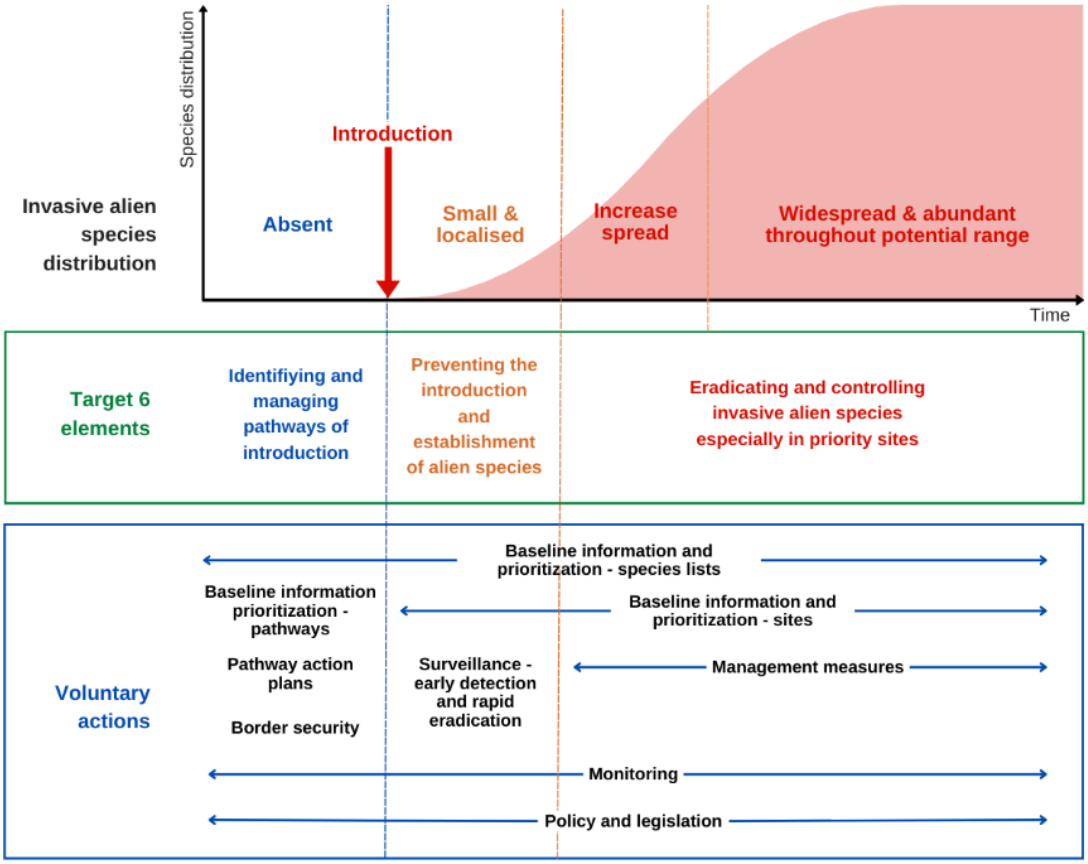
21. When developing and implementing these actions, it is important that a cross-sectoral approach is taken, that recognises the broad impacts many invasive alien species also have across agriculture and other economic sectors, and human health and wellbeing. It is likely that relevant measures are already being implemented through these sectors, for example biosecurity procedures to protect agriculture and aquaculture from pests and diseases, and they present opportunities for synergies and collaboration to ensure that threats to biodiversity are also addressed. See section 2.4 below that sets out the broader considerations for implementing actions for Target 6.

22. While the actions set out in this toolkit can be implemented independently, it is recommended that they are developed as part of a formal national invasive species strategy that will improve the governance of invasive alien species management. Such an approach can be taken by explicitly including actions addressing Target 6 within the National Biodiversity Strategy and Action Plan (NBSAP), or by developing a more comprehensive and cross-sectoral **National Invasive Species**

**Strategy and Action Plan (NISSAP).**[70] Addressing invasive alien species through the development and implementation of a NISSAP will improve the likelihood that a strategic approach is taken, so that the correct priorities are being addressed in the most cost-effective way, that measures are sustainable and adaptable to reflect changing circumstances, and that a cross-sectoral integrated governance approach is taken.[71] **Enclosure 3 presents guidance on how to develop a NISSAP**. It takes the actions to meet Target 6 presented in the Toolkit and places them alongside other additional measures within a holistic strategic framework to develop and implement a NISSAP.

Figure III

**How the different actions (blue box) address different elements of Target 6 (green box), and the corresponding invasion stages**




### (i) Actions for compiling baseline information and prioritizing invasive alien species, pathways of introduction, and sites

23. Compiling and analysing available baseline information on alien and invasive alien species, pathways of introductions, and sites will inform all actions towards Target 6. Having access to this information will mean that the actions taken to prevent the introduction and establishment, and management of invasive alien species will be built on the best available evidence and therefore more

[70] Decision VI/23 reaffirms the importance of national and regional invasive alien species strategies and action plans to address the threats posed to biodiversity of invasive alien species.

[71] The IPBES thematic assessment on invasive alien species (2023) defines *integrated governance for biological invasions* as the establishment of relationships between the roles of actors, institutions and instruments, and involving as appropriate all those elements of the socio-ecological system that characterize biological invasion and its management, for the purpose of identifying the strategic interventions needed to improve invasive alien species prevention and control outcomes (definition originated from this assessment, from the thinking on integrated environmental governance).

likely to be effective. It is important to stress that knowledge gaps will always exist, and these should not stop action being taken.

**Guiding questions that will be answered:**

- What alien species have we got, how and when did they get here (pathways of introduction), and what are their impacts?
- What alien species might arrive in the near future, how could they arrive (pathways of introduction), and what might their impacts be?
- What sites are susceptible to introductions and establishments, or vulnerable to impacts from invasive alien species?
- Which alien species, pathways of introduction, and sites should we be concerned about the most?

24. Before starting to compile baseline information, it is important to note that it is likely that other actors possess relevant information and should be engaged with, if possible. This includes for instance, national and sub-national government agencies, such as those responsible for protected areas or inland waters, agriculture, forestry, and fisheries. In addition, indigenous peoples and local communities, academic institutions, and civil society organisations, especially those with responsibility for land management, may be able to provide useful information. Identifying who has relevant information will require an integrated governance approach to ensure that the baseline information is as comprehensive as possible.

*Species lists*

25. A list incorporating current and future alien species is the fundamental building block to support the prioritisation needed for developing many of the actions towards meeting Target 6.

26. Information on the invasive alien species that are currently known or suspected to have the greatest impacts upon nature in the country is usually the most accessible, and a good place to start. This can be extended to include a longer list of alien species known to have been recorded in the country. As a starting point, there are freely available global and regional databases including the Global Register of Introduced and Invasive Species - GRIIS[72] which provides validated national checklists of alien species. Additionally, the Alien Species First Record Database[73] can also provide information on first records, if available. To help in the prioritisation process, additional information such as evidence of environmental and socio-economic impacts,[74] and the plausible pathways of introduction, will be useful to collate if available. Alien species lists do not need to be complete to be useful, partial lists can provide a good starting point for informing actions. If feasible, the establishment of a national database of alien species, using commonly accepted standardised terminology, will support efforts to meet Target 6, including in prioritisation, monitoring, and management.

27. To generate a list of alien species not yet present, but likely to be introduced in the near future, a horizon scanning approach can be used.[75] This usually adopts a structured process involving expert

[72] The Global Register of Introduced and Invasive Species - GRIIS. Produced by the IUCN SSC Invasive Species Specialist Group (ISSG) within the framework of activities of the Global Invasive Alien Species Information Partnership (GIASIP) https://griis.org/ (also available via GBIF https://doi.org/10.15468/puy8bx)

[73] Seebens, H., Blackburn, T.M., Dyer, E.E., (2017). No saturation in the accumulation of alien species worldwide. *Nature Communications*, Vol. 8 (February) https://doi.org/10.1038/ncomms14435. The Global Alien Species First Record Database resulting from this paper can be found here: https://dataportal.senckenberg.de/dataset/global-alien-species-first-record-database

[74] Classifying alien species in terms of the magnitude of their environmental impacts can be done by applying the IUCN Environmental Impact Classification for Alien Taxa - EICAT Categories and Criteria https://doi.org/10.2305/IUCN.CH.2020.05.en. Note that all global EICAT assessments are made available on the IUCN Global Invasive Species Database. https://www.iucngisd.org/gisd/

[75] See for example: Roy, H.E., Peyton, J., Aldridge, D.C., *et al.* (2014). Horizon scanning for invasive alien species with the potential to threaten biodiversity in Great Britain. *Global Change Biology;* Vol. 20, Issue 12 (December)

elicitation and consensus building and does not need to be comprehensive to be informative, as it can focus on specific taxonomic groups, realms or pathways that are of most concern. There are a number of global and regional databases that can assist in identification of the alien species not yet introduced or established, their pathways of introduction, likelihood of introduction and establishment, and potential impacts (see enclosure 2, resources).

28. This information can be used to support the prioritisation of high-risk species that may require regulation or contingency planning to prevent introduction and establishment, and of species for eradication or control to eliminate or reduce their impacts. For species that are not yet established, a formal risk assessment can be undertaken. This is a systematic and evidence-based process that considers the separate steps within the biological invasion process and potential impacts of species, evaluating each step and determining the overall risk. The level of detail of information included in the risk assessment will depend on the intended use, for example those used to support legislation (e.g. banning trade) will usually need to be more detailed. There are several existing risk assessment templates and processes that can be adopted.[76] In addition, a risk management approach can be taken to assess the feasibility of management options if the species are introduced. This allows efforts and resources to be focused on those invasive alien species that have both a high risk of introduction, establishment and impact, and that can be eradicated or controlled if they arrive. A risk management approach can also be used alongside evidence of impacts, to help prioritize those invasive alien species that are already established in a territory. This will identify those invasive alien species where eradication, containment or control is a feasible management option, particularly within priority sites.

29. This list of established alien species, updated via monitoring and survey effort to identify new introductions and establishments, will also allow for monitoring changes in the rates of establishment, which is the headline indicator for Target 6 (see section 2.5).

*Pathways of introduction*

30. Identifying the pathways of introduction of past and future alien species introductions into the territory is the first step towards developing pathway action plans. Ideally this information will be collated during the generation of the species lists and will use the standardised pathway terminology and classification produced under the Convention.[77] It is likely that evidence for the pathways responsible for most of the alien species introductions does not exist, however, this information can be deduced by expert opinion and by pathways allocated to the introduction of the species from other countries or in global datasets (see Enclosure 2 Resources). In addition, choosing the relevant pathways to assign can sometimes be challenging, therefore additional guidance[78] has been produced to support this process.

31. This information will allow the priority intentional and unintentional pathways of introduction to be identified. Depending on data availability, this can be achieved by identifying those pathways

https://doi.org/10.1111/gcb.12603; Roy, H.E,, Bacher, S., Essl, F., *et al*. (2019). Developing a list of invasive alien species likely to threaten biodiversity and ecosystems in the European Union. *Global Change Biology;* Vol 25, Issue 3 (March) https://doi.org/10.1111/gcb.14527

[76] For example: The EU invasive alien species Risk Assessment process and framework, see Commission Delegated Regulation (EU) 2018/968 http://data.europa.eu/eli/reg_del/2018/968/oj, Roy, H.E., Rabitsch, W., Scalera, R., *et al.* (2017). Developing a framework of minimum standards for the risk assessment of alien species. *Journal of Applied Ecology*, Vol. 55, Issue 2 (March) https://doi.org/10.1111/1365-2664.13025; ISPM 11, Pest Risk Analysis for quarantine pests is an international standard to assess the risk of pests or alien plants becoming invasive; WOAH import risk analysis for assessing the disease risks associated with the importation of animals, animal products etc.; the Great Britain Non-Native Species Secretariat – GB NNSS. Risk assessment templates and species assessments; and Kumschick, S., Wilson, J.R.U, and Foxcroft, L.C.. (2020). A framework to support alien species regulation: the Risk Analysis for Alien Taxa (RAAT). *NeoBiota*, Vol 62 (October) https://doi.org/10.3897/neobiota.62.51031

[77] See CBD SBSTTA/18/9/Add.1. Pathways of introduction of invasive species, their prioritization and management.

[78] European Commission, Directorate-General for Environment, Harrower, C., Scalera, R., Pagad, S. *et al., Guidance for interpretation of the CBD categories of pathways for the introduction of invasive alien species*, Publications Office, 2020. https://data.europa.eu/doi/10.2779/6172

with the highest number of species introductions, highest volume of traffic, and/or responsible for invasive species leading to the highest magnitude of impacts.[79]

*Sites*

32. Target 6 requires that invasive alien species are eradicated or controlled in priority sites, such as islands. In order to identify those priority sites, it is important to understand which sites are more susceptible to introductions, and which are sensitive (or vulnerable) to impacts from invasive alien species.[80] *Sensitive sites* or areas are those where the greatest impacts upon nature will be realised if invasive alien species are able to establish. These sites need to be identified at a national level, but could include protected areas, natural World Heritage Sites, Key Biodiversity Areas, islands, and isolated freshwater systems. *Susceptible sites* are those areas that are at high risk to the introduction and establishments of alien species. These are often areas that are already degraded and close to areas of high levels of human activity, e.g. ports and harbours, large urban areas, tourist sites, or major traffic routes. These sites should be prioritized for biosecurity efforts to prevent species being introduced, for surveillance so that early detection and rapid eradication can prevent new invasive alien species establishing, and be the focus of management actions to remove, minimize and mitigate impacts from existing invasive alien species.

### (ii) Actions for managing pathways of introduction

33. Prevention is the most cost-effective way to mitigate impacts from invasive alien species. By managing the priority pathways of introduction, the risk of a species being transported and introduced into a country can be reduced.

**Guiding questions that will be answered:**

- What can we do to prevent invasive alien species from being introduced?

*Pathway action plans*

34. Building on the pathway identification and prioritisation covered in the above section on baseline information, the pathways that will be the target of action plans need to be chosen. The final selection should also consider the feasibility of managing the pathways, so that pathways are not chosen where it is unlikely that any measures taken would prevent introductions.

35. Pathway action plans set out the strategic actions that need to be undertaken and can target an individual pathway, or a group of related pathways. If targeting a group of pathways, it is important to ensure that actions are proposed for each individual pathway, or that it is clearly indicated to which pathway they refer to. Ideally, pathway action plans will be developed in consultation with the key stakeholders that will be needed to implement actions or will be affected by them. Given the diverse nature of different pathways, action plans can include a range of activities including raising public awareness, policy development, improving the effectiveness of border checks for specific goods, or applying best practices to reduce contamination of commodities, equipment or vehicles. They can also target both pathways of introduction into a country, and pathways of spread for species that are already introduced. Pathway action plans often target unintentional introductions, as often legislation can be used to regulate the import, trading, keeping and breeding of invasive alien species that are intentionally introduced. Guidance has been developed through the Council of Europe to support countries in the development of pathway action plans[81] and, while these guidelines are for European

[79] Examples of pathway analysis: NOBANIS. 2015. Invasive alien species pathway analysis and horizon scanning for countries in Northern Europe. Nordic Council of Ministers, Copenhagen. doi:10.6027/TN2015-517; Rabitsch *et al*. 2018. Analysis and prioritisation of pathways of unintentional introduction and spread of invasive alien species in Germany in accordance with Regulation (EU) 1143/2014. https://www.bfn.de/en/publications/bfn-schriften/bfn-schriften-490-analysis-and-prioritisation-pathways-unintentional

[80] McGeogh, M.A., Genovesi, P., Bellingham, P.J, *et al.* (2016). Prioritising species, pathways, and sites to achieve conservation targets for biological invasion. *Biological Invasions*, Vol. 18 (November) https://doi.org/10.1007/s10530-015-1013-1

[81] Council of Europe. (2016). Guidance for governments concerning invasive alien species pathways action plans. Convention on the Conservation of European Wildlife and Natural Habitats, Standing Committee. https://rm.coe.int/1680746339

countries, they are still relevant globally. In addition, there are existing guidance documents, or codes of conduct, that can be used to inform the development of actions for specific pathways, see the resources section for this.

36. Due to the international nature of pathways, collaboration at the regional or international level will support their management. In addition, some pathways are already addressed by existing international agreements[82] and the relevant national authorities need to be engaged with to develop any additional actions that may be needed.

**(iii) Actions for preventing the introduction and establishment of alien species**

37. Pathway management will not prevent all introductions of alien species, therefore additional actions are needed to prevent their introduction and establishment. Implementing biosecurity procedures, including border security measures along with early detection and rapid response capability, is more cost-effective at preventing impacts from invasive alien species than managing them once they become established. Some of the actions described here may have been included within the pathway action plans discussed above.

**Guiding questions that will be answered:**

- What can we do to prevent alien species from being introduced and establishing?

*Border security*

38. Effective border security measures (often termed 'biosecurity') will reduce the risk of introductions and spread of alien species across many pathways of introduction, and can be applied pre-border, at-border, and post-border. As invasive alien species have broad scale impacts across sectors, it would be beneficial to take a 'one-biosecurity' approach[83] if feasible, where relevant national authorities responsible for identifying and managing risks to the environment and biodiversity, agriculture, and human health are working together.

- **Pre-border** – These are actions taken outside of the country or region to reduce the risk of alien species being transported in the first place. This could range from preventing exports from certain high-risk places or along certain pathways, working with trading partners to raise awareness and improving inspection and treatment procedures prior to export, or the application of compliance systems such as 'passports' to verify that biosecurity standards have been met.
- **At border** – The most fundamental elements of border security are the physical inspections and checks of goods, equipment, and people entering a country. These can ensure that regulated species are not imported deliberately, or as contaminants on other goods. Existing capacity will likely exist to cover requirements for plant and animal health, and it may be feasible to expand their mandates and expertise to also cover invasive alien species that threaten biodiversity. For most countries all goods and consignments cannot be checked due to the high volume of imports, therefore the focus of inspections should be 'risk based' and focused on the relevant alien species and pathways that have been prioritized. It is also important to have suitable facilities and infrastructure to allow for inspections and quarantine to be undertaken.
- **Post-border** - It is not always possible to detect and stop regulated species at the border, and so it is important to carry out post-border inspections to check for regulated species within the country. These could include visiting premises that may keep, trade or transport regulated species to ensure they are complying with national laws.

[82] Examples of existing international agreements relevant to invasive alien species pathways of introduction: World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures (WTO-SPS Agreement), World Organisation for Animal Health (WOAH), International Plant Protection Convention (IPPC), International Convention for the Control and Management of Ships' Ballast Water and Sediments (the Ballast Water Management Convention, BWM)

[83] Hulme, P.E. (2020). One Biosecurity: A unified concept to integrate human, animal, plant, and environmental health. Emerging Topics in Life Sciences, Vol 4, Issue 5 (December).

*Surveillance for early detection*

39. Surveillance to rapidly detect new alien species is important to ensure the effectiveness of rapid response and eradication. Surveillance systems can be designed to detect many different invasive alien species or can be specific to one or a few invasive alien species selected through horizon scanning and risk assessment.

40. Surveillance can be implemented for priority invasive alien species and/or at susceptible and vulnerable sites. The design of surveillance programmes, including the methods used and effort required, will be determined by the detectability of the species being targeted, and its habitats. Cryptic and harder to detect species at a low density will require a greater level of surveillance. 'Sentinel' sites or networks can also be established, where heightened levels of surveillance are undertaken at selected areas (e.g. at susceptible sites) in order to enhance detection and improve cost-effectiveness. To be effective, surveillance programmes need to have access to species identification capacity. 'Citizen-science' programmes can be a cost-effective tool for helping collate useful information on invasive alien species, especially for early detection and species distribution mapping.[84] Reporting by the public can be realised through a dedicated email account, social media or smart phone apps, however it is critical that someone has the responsibility to check the reports, and also ensure the information is validated and sent to the relevant authority, so that action is taken. In addition, there are many innovative technologies such as smart traps, sensor networks and eDNA that can also be used to support surveillance efforts for early detection.[85]

*Rapid response capacity to eradicate new incursions*

41. In general, the likelihood of eradication being feasible declines following the dispersal of the invasive alien species. As different species establish and spread at different rates (e.g. hornets versus trees), the time frame between introduction and when eradication is no longer feasible will differ. It is therefore useful to prepare rapid response plans for priority species that set out the institutional responsibilities, response processes, and access to resources and capacity, so that an invasive alien species incursion can be cost-effectively, and as soon as possible, eradicated or contained following on from an early detection. These plans can be generic, for example targeting broad species groups, such as terrestrial vertebrates,[86] or be species specific.

*Biosecurity legislation and policy*

42. Having robust and effective legislation and policies will underpin actions to prevent the introduction and establishment of alien species and will provide the required mandates for institutions, including for collaboration across sectors. Such legislation may also regulate the keeping, releasing, importing and trading of priority invasive alien species. There may already exist relevant legislation that covers other sectors, such as for plant and animal health, and it may be more feasible to amend these to cover invasive alien species that impact biodiversity, than to create new specific legislation. Examples of the elements that can be covered by biosecurity legislation include the provision of powers to undertake inspections and quarantine goods, seizure of regulated species or contaminated goods, establishing financial penalties, and entry to private land or vessels to undertake inspections, surveillance or eradication measures.[87]

[84] Pocock, M.J.O., Adriaens, T., Bertolino, S., *et al.* (2024). Citizen science is a vital partnership for invasive alien species management and research. *iScience*, Vo. 27, Issue 1 (January) https://doi.org/10.1016/j.isci.2023.108623

[85] Martinez, B., Reaser, J.K., Dehgan, A., *et al.* (2020). Technology innovation: advancing capacities for the early detection of and rapid response to invasive species. *Biological invasions*, Vol. 22 (December) https://doi.org/10.1007/s10530-019-02146-y

[86] For example, the GB Non-Native Species Secretariat (GB NNSS) have produced five generic rapid response plans ('contingency plans') for Great Britain to address incursions for terrestrial vertebrates, terrestrial plants, freshwater plants, aquatic animals, and marine species.

[87] To support the UK Overseas Territories develop biosecurity capacity, the GB NNSS have produced model biosecurity legislation along with a legal checklist which is intended to provide a comprehensive list of elements which together comprise effective biosecurity legislation.

### (iv) Actions for the eradication and control of invasive alien species

43. Undertaking actions that aim to eradicate, contain, or control established invasive alien species populations are the main means of eliminating, minimising or reducing their impacts. Target 6 calls for these actions to be applied especially in priority sites and should therefore be informed by the prioritisation process discussed above. Ongoing monitoring and evaluation will provide updates on the status of biological invasions and progress of any interventions to allow review of priorities, resource allocation and adaptation of management methods.

> **Guiding questions that will be answered:**
>
> What can we do to eliminate, minimize or mitigate impacts from invasive alien species?

*Management measures*

44. In order to eliminate, minimise, or mitigate the impacts of currently established invasive alien species, especially within priority vulnerable sites, management measures need to be undertaken. When planning and undertaking these management measures, there are three broad objectives that should be considered:

- **Eradication** - Remove the entire population of an invasive alien species from a defined geographic area, with no immediate risk of re-invasion.
- **Containment** - Prevent the spread of a population of an invasive alien species from a defined area. Containment may also apply in the context of keeping an invasive alien species out of a defined geographic region within a broader landscape (also known as 'exclusion').
- **Control** - Reduce the abundance, distribution, or spread and impacts of a population of an invasive alien species from a defined geographic area of interest.

45. *Eradication* of the invasive alien species population should be considered as the first option. This is because eradication, if successful, will eliminate the impacts from the invasive alien species rather than reducing them, and the measures being implemented will be time bound, meaning that costs, side effects and any welfare impacts will be less than if the invasive alien species population is controlled in the long term. Where eradication is not deemed to be feasible, either for costs, effectiveness or other reasons such as political or community support, then *containment* or *control* should be considered. In terrestrial environments increasingly larger scale eradication programmes have been successful, especially those that target mammal invasive alien species on islands,[88] resulting in significant conservation outcomes. In freshwater systems, eradication is more challenging, but has been achieved primarily in smaller isolated water bodies. However, eradications in the marine environment are largely unfeasible, highlighting the importance of pathway management to prevent introductions in the first place.

46. There are many management measures available that can be used to eradicate, contain or control invasive alien species[89] and their effectiveness depends upon many factors, including the species being targeted and the habitats it is found, the size of area being managed, available resources and capacity, legal frameworks, and political and community support. The involvement of stakeholders and communities in the planning and decision-making processes is fundamental, as it usually leads to an increase in the likelihood of success.

47. In addition, taking an adaptive integrated approach, where more than one option is used either in parallel or sequence (e.g. mechanical removal followed by herbicide application), can achieve greater success than the application of either option on their own. This approach can also include the

[88] Spatz *et al.* 2022. The global contribution of invasive vertebrate eradication as a key island restoration tool. *Scientific Reports*. https://doi.org/10.1038/s41598-022-14982-5

[89] For example see: Sankaran, K., Schwindt, E., Sheppard, A.W., *et al.* (2023). Chapter 5: Management; challenges, opportunities and lessons learned. In: Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H. E., Pauchard, A., Stoett, P., and Renard Truong, T. (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430733

use of ecosystem management approaches (e.g. restoring connectivity or flow regimes in a river) alongside actions that directly target the invasive alien species.

*Monitoring*

48. The integration of new data on the introduction and establishment of new alien species, and the distribution, spread and impacts of existing invasive alien species, especially within priority sites, into baseline datasets is essential to provide up-to-date lists of species and their impacts and on the effectiveness of prevention and management measures. Standardised monitoring should be implemented for:

- **Invasive alien species and sites** – To track introduction and establishment of new species, established species spread and impacts.
- **Pathways** – To track success of prevention measures such as biosecurity inspections, regulations and compliance.
- **Management actions** - All management interventions (prevention, eradications and control) should be monitored for cost and effectiveness.

49. These data will allow for tracking of progress towards Target 6, and to inform decision making and resource allocation to adapt any actions being taken.

*Policy and legislation for management of invasive alien species*

50. Legislation at a national level may already exist that deals with aspects of the management of biological invasions, directly or indirectly. These are likely to be primarily targeting different sectors such as plant and animal health, shipping, aquaculture, forestry, and trade and transport. It is important to understand the current legal framework and what gaps exist, as new invasive alien species specific legislation that covers both prevention and management may be needed. It is also important to ensure alignment and coordination across sectors and regulatory instruments, in order to support the management of invasive alien species. As discussed above in relation to biosecurity, such legislation or policies should identify which institutions have the mandate to act, and can provide powers to access private land, for cost recovery, and to regulate what management methods can be used.

## 2.4 Considerations for the implementation of Target 6

51. Considering the cross-cutting nature of the challenges posed by invasive alien species, for actions towards Target 6 to be effective they need to consider additional considerations beyond the specific actions focused on the Target. Many of these are set out in Section C of the Framework.[90] This section presents some examples on how some of the actions from Section C could be applied to support the achievement of Target 6.

### 2.4.1 Whole-of-government and whole-of-society approach

52. In order to meet Target 6 a whole-of-government and whole-of-society approach needs to be taken. This is especially important due to the cross-sectoral and cross-border nature of invasive alien species and the many different institutions that undertake measures that aim to prevent or address their impacts. In addition, there are instances where there will be conflicting perceptions of the value of invasive alien species, and the ethics associated with their management. It is critical that relevant actors and institutions across different sectors co-ordinate, collaborate and build partnerships with each other to strategically manage invasive alien species.

53. Addressing the challenges posed by invasive alien species will require engagement, coordination and joint policy development across multiple sectors (e.g., environment, agriculture, plant and animal health, transport, trade, customs, tourism, science and research, and human health departments), at both national and sub-national levels. Taking a whole-of-government approach, potentially supported by a single cross-sector coordination body, will strengthen the understanding

[90] Introduction to the Framework https://www.cbd.int/gbf/introduction.

of invasive alien species and their cross-sectoral impacts and facilitate the development and implementation of coherent policies and legislation, national strategies and action plans, and funding mechanisms to strengthen measures that prevent the introduction and spread of invasive alien species and eliminate or mitigate their impacts.

54. This approach includes the involvement of the private sector and civil society. Many intentional and un-intentional pathways of introduction are related to key sectors. The development and effective implementation of best practices and voluntary codes of conduct, implementing biosecurity measures across the supply chain, and the adherence to national legislation and regional and international policy instruments can play a major role in preventing future impacts from invasive alien species. Civil society organisations can help change the perception of invasive alien species and build support for management actions.

### 2.4.2 Contribution and rights of indigenous peoples and local communities

55. The Framework acknowledges the important roles and contributions of indigenous peoples and local communities as custodians of biodiversity and as partners in its conservation, restoration and sustainable use.[91] Indigenous peoples and local communities own or govern 32 per cent of the world's land which supports a third of the world's Key Biodiversity Areas.[92] However, more than 2,300 invasive alien species are found on lands managed, used and/or owned by indigenous peoples, threatening their quality of life.[93] It is therefore essential to ensure that the rights, knowledge, including traditional knowledge associated with biodiversity, innovations, worldviews, values and practices of indigenous peoples and local communities are respected, and documented and preserved with their free, prior and informed consent, including through their full and effective participation in decision-making.

### 2.4.3 National circumstances, priorities and capabilities

56. Actions towards addressing invasive alien species should be implemented according to each Parties national circumstances, priorities and capabilities. For example, the identification of priority invasive alien species that may arrive in the near future will differ based on many factors such as trade relations, the prioritisation of sites will depend upon national conservation objectives, and measures put in place to prevent introduction and establishment, and the eradication and control of invasive alien species will depend upon access to resources and expertise, and existing legislation and policy frameworks.

### 2.4.4 Interactions with other drivers of biodiversity loss

57. The interactions between invasive alien species and other direct drivers of biodiversity loss such as climate change, pollution, habitat loss, and exploitation need to be acknowledged and understood as they are known to facilitate the establishment and spread of invasive alien species.[94] For example, a changing climate can create new opportunities for alien species to become invasive, including via floods and fires that are becoming more frequent and severe in many parts of the world. Conversely, the impacts from invasive alien species can reduce the resilience of natural habitats,

[91] Decision 15/4, Kunming-Montreal Global Biodiversity Framework – Section C. Considerations for the implementation of the Kunming-Montreal Global Biodiversity Framework.

[92] WWF, UNEP-WCMC, SGP/ICCA-GSI, LM, TNC, CI, WCS, EP, ILC-S, CM, IUCN. (2021). The State of Indigenous Peoples' and Local Communities' Lands and Territories: A technical review of the state of Indigenous Peoples' and Local Communities' lands, their contributions to global biodiversity conservation and ecosystem services, the pressures they face, and recommendations for actions Gland, Switzerland. https://wwflac.awsassets.panda.org/downloads/report_the_state_of_the_indigenous_peoples_and_local_communities_lands_and_territories_1.pdf.

[93] IPBES. (2023). Summary for Policymakers of the Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H.E., *et al.* (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430692.

[94] IPBES. (2023). Summary for Policymakers of the Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H.E., *et al.* (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430692

agricultural systems, and urban areas to climate change. Understanding these links is critical so that a coherent and integrated response can be undertaken, and also that policies and actions that aim to address one driver do not exacerbate the impacts of another, for example by planting of potentially invasive alien tree species in order to increase carbon capture and sequestration.

### 2.4.5 Consistency with international agreements or instruments

58. Taking action to address invasive alien species needs to be implemented in accordance with relevant international obligations. This includes:

- *Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).* Under CITES the, the Conference of the Parties have adopted Resolution Conf. 13.10 (Rev. CoP14) on Trade in alien invasive species.[95] In this Resolution, the CoP is recommending that countries consider the problems of invasive alien species when developing national legislation and regulations that deal with the trade in live animals or plants. Further, when possible and applicable, the designated Management Authority of the country of export should consult with the Management Authority of a proposed country of import, when considering issuing an export permit to authorize the export of potentially invasive species, for the importing country to be able to determine whether there are domestic measures regulating such imports.
- *The International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 (BWM Convention).* The aim of the BWM Convention.[96] which has been in force since September 2017, is to prevent the transfer of invasive aquatic species by shipping, specifically through ballast water, by establishing standards and procedures for the management and control of ships' ballast water and sediments. Under the Convention, all ships in international traffic are required to manage their ballast water and sediments to a certain standard, according to a ship-specific ballast water management plan. Ships cannot discharge ballast water into the sea unless it has been managed in accordance with the provisions of the BWM Convention; ultimately this entails complying with a strict quantitative discharge standard.
- *The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement).* The SPS agreement[97] sets out the basic rules on food safety and animal and plant health standards that governments are required to follow. These standards must be based on science, applied only to the extent necessary to protect human, animal or plant life or health, and not arbitrarily or unjustifiably discriminate between countries. The SPS Agreement encourages members to base their sanitary and phytosanitary measures on international standards, and recognises the IPPC and WOAH as the relevant standard setting organisations for plant and animal health respectively. If no relevant international standard exists, or when a WTO member wishes to deviate from an existing international standard, measures have to be based on a risk assessment that evaluates the of the likelihood of entry, establishment or spread within the territory of an importing member, and of the potential impacts on biological diversity and socioeconomic values.
- *The World Organisation for Animal Health (WOAH).* WOAH develops normative documents relating to rules that Member Countries can use to protect themselves from the introduction of diseases and pathogens, without setting up unjustified sanitary barriers. The main normative works produced by WOAH are the following standards:[98] the Terrestrial Animal Health Code, the Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, the Aquatic Animal Health Code and the Manual of Diagnostic Tests for Aquatic Animals.

[95] CITES Resolution Conf. 13.10 (Rev. CoP14) on Trade in alien invasive species https://cites.org/sites/default/files/documents/COP/19/resolution/E-Res-13-10-R14.pdf
[96] IMO Ballast Water Management Convention https://www.imo.org/en/OurWork/Environment/Pages/BallastWaterManagement.aspx
[97] WTO Sanitary and Phytosanitary measures https://www.wto.org/english/tratop_e/sps_e/sps_e.htm
[98] WOAH standards https://www.woah.org/en/what-we-do/standards/.

They are prepared by elected Specialist Commissions and by Working Groups bringing together internationally renowned scientists, most of whom are experts within the network of about 246 Collaborating Centres and Reference Laboratories that also contribute towards the scientific objectives of WOAH. These standards are adopted by the World Assembly of Delegates. WOAH standards, guidelines and recommendations are recognised by the World Trade Organization (SPS agreement) as the reference documents for Countries to base their sanitary measures necessary to protect animal life or health.

- *The International Plant Protection Convention (IPPC).* The IPPC promotes action to protect plants and plant products from the spread of pests and sets out measures to control plant pests. To protect the world's cultivated and natural plant resources from the spread and introduction of plant pests while minimizing interference with the international movement of goods and people, the International Plant Protection Convention provides an international framework for plant protection that includes International Standards for Phytosanitary Measures (ISPMs).[99] ISPMs provide guidance on phytosanitary principles for the protection of plants, and the application of phytosanitary measures in international trade, with specific standards covering: pest risk analysis, import and export systems, post-border controls, and surveillance and reporting on pests and diseases.

### 2.4.6 Biodiversity and health

59. Invasive alien species can be vectors of pathogens, or in some cases be pathogens, that impact wildlife and can also affect human, and domesticated animal and plant health. In addition, their impacts upon the quality and quantity of ecosystem services can affect livelihoods and food and water security. Understanding the interlinkages between health and invasive alien species and their management will strengthen the development of interdisciplinary actions such as a 'One Biosecurity' approach,[100] which addresses risks that cut across human health, agriculture, and the environment.

## 2.5 Indicator for the implementation of Target 6

60. While it is critical to establish national or regional indicators to implement this Target, it is important to consider that, at an international level, the headline indicator for Target 6 refers to the rate of invasive alien species establishment,[101] which quantifies the number of invasive alien species that are expected to have established in a new region or country over the reference period. The unit of measurement is the rate of invasive alien species establishments per unit period (e.g. year). The indicator measures the change in this rate of IAS establishment. The indicator can be disaggregated by taxon, subnational unit (e.g. islands), priority conservation areas, pathways, or type of impact.

61. The unit of measure for this indicator is the rate of invasive alien species establishments (number/year). From this the trend in the rate of change for the reporting period can be estimated. This indicator links the management success of introduction pathways of invasive alien species to the desired outcome to prevent new country establishments.

62. A critical source of information for this indicator is the IUCN Global Register of Introduced and Invasive Species as well as the Alien Species First Record Database (Seebens *et al*. 2017) which can be used as baseline. Based on national monitoring processes, research, citizen science, etc. Parties can also contribute to enrich these international tools by providing them with information on newly detected species.

63. Country actions towards Target 6, should consider the use of this indicator to monitor their progress.

[99] IPPC international Standards for Phytosanitary Measures (ISPMs) https://www.ippc.int/en/core-activities/standards-setting/ispms/.
[100] Hulme, P.E. (2020). One Biosecurity: A unified concept to integrate human, animal, plant, and environmental health. *Emerging Topics in Life Sciences*, Vol 4, Issue 5 (December).
[101] Decision 15/5.

# Enclosure 1

# Toolkit glossary

The present enclosure presents a list of some key invasive alien species related terms used in this toolkit. These terms and their definitions are taken from the decisions of the Conference of the Parties to the Convention on Biological Diversity and the IAS glossary[102] on the website of the Convention and the glossary section of the *Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*[103] (IPBES 2023). Please see these resources for additional IAS related terms and definitions.

| Term | Definition | Source |
|---|---|---|
| Alien species | A species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce. | CBD COP Decision VI/23[104] |
| Invasive alien species | An alien species whose introduction and/or spread threaten biological diversity | CBD COP Decision VI/23 |
| Introduction | The movement by human agency, indirect or direct, of an alien species outside of its natural range (past or present). This movement can be either within a country or between countries or areas beyond national jurisdiction; | CBD COP Decision VI/23 |
| Intentional introduction | the deliberate movement and/or release by humans of an alien species outside its natural range | CBD COP Decision VI/23 |
| Un-intentional introduction | All other introductions which are not intentional, | CBD COP Decision VI/23 |
| Pathway of introduction | A suite of processes that result in the introduction of a species from one geographical location to another. It means: 1) geographic routes by which a species is moved outside its natural range (past or present); 2) corridors of introduction (e.g., road, canal, tunnel); and/or 3) human activity that gives rise to an intentional or unintentional introduction. More than one vector within a pathway may be involved in a transfer of species | IPBES 2023 |
| Biological invasion (or invasion process) | A process involving the transport of a native species outside of its natural range, intentionally or unintentionally, by human activities to new regions where it may become established, spread and ultimately adversely impact nature, nature's contributions to people, and good quality of life (Blackburn *et al.*, 2011; Figure 1.6). | IPBES 2023 |
| Surveillance | actions, including extended programme of surveys and general surveillance (capturing unstructured and untargeted surveillance data and information from a wide range of sources), undertaken in order to directly or indirectly detect the presence of one or many invasive alien species over time (CEPM, 1996; Clift, 2008; CPM, 2015). | IPBES 2023 |
| Monitoring | he continued or regular observation of an ecosystem to detect invasion/reinvasion by invasive alien species and/or their impacts. | IPBES 2023 |

[102] https://www.cbd.int/invasive/terms.shtml
[103] https://www.ipbes.net/ias
[104] CBD/COP/DEC/VI/6

| Term | Definition | Source |
|---|---|---|
| Adaptive management | A philosophy that accepts that management must proceed even without complete information. It views management not only as a way to achieve objectives, but also as a process for probing to learn more about the resource or system being managed. Learning is an inherent objective of adaptive management. Adaptive management is a process where policies and activities can adapt to future conditions to improve management success (CCBA, 2008). | IPBES 2023 |
| Biosecurity | a strategic and integrated approach that encompasses the policy and regulatory frameworks (including instruments and activities) for identifying, analysing and managing risks, including invasive alien species, to human, animal and plant life and health, and associated risks to the economy and the environment (FAO, 2007). | IPBES 2023 |
| Containment | the application of measures in and around an infested area to prevent spread of invasive alien species. Containment may also apply in the context of keeping an invasive alien species out of a defined geographic region within a broader infestation (in pest management this is also termed "area-wide management") (FAO, 2019). Any action taken to delimit the distribution of an invasive alien species through whatever means possible. | IPBES 2023 |
| Control | direct action(s) taken to reduce or suppress the distribution, abundance, spread and impacts of invasive alien species within a defined geographic area (FAO, 1995) (see management). | IPBES 2023 |
| Eradication | elimination/extirpation of an invasive alien species from a defined geographic area even in the absence of all preventive measures obviating the necessity for further control measures (Dowdle, 1998). The time period after which an invasive alien species can be considered eradicated depends on the species and location. | IPBES 2023 |
| Establishment / established alien species | The process of an alien species in a new habitat successfully producing viable offspring with the likelihood of continued survival | CBD COP Decision VI/23 |
| Integrated governance for biological invasions | establishment of relationships between the roles of actors, institutions and instruments, and involving as appropriate all those elements of the socio-ecological system that characterize biological invasion and its management, for the purpose of identifying the strategic interventions needed to improve invasive alien species prevention and control outcomes (definition originated from this assessment, from the thinking on integrated environmental governance). | IPBES 2023 |
| Invasion stages: | stages (transport, introduction, establishment, and spread) that a species must pass through on the invasion continuum from native to (invasive) alien species, recognising the need for a species to overcome the barriers (geography, captivity or cultivation, survival, reproduction, dispersal and environmental) that obstruct transition between each stage (Blackburn *et al.*, 2011). | IPBES 2023 |
| Management | any action taken to address the threats, risks, distribution, abundance and impacts of an invasive alien species within a defined geographic area (Hulme, 2006; Pyšek *et al.*, 2020). Management includes prevention, preparedness, | IPBES 2023 |

| Term | Definition | Source |
|---|---|---|
| | eradication, containment, and control (Robertson *et al.*, 2020). | |
| Pathway management | any action taken (single or via systems approach) towards a particular anthropogenic invasive alien species arrival pathway (e.g., trade) to prevent or address the threats and risks of an invasive alien species arriving and establishing via that pathway either between or within jurisdictions (Robertson *et al.*, 2020). | IPBES 2023 |
| Prevention | any policy and/or action/response undertaken to prevent the arrival and/or introduction of alien and invasive alien species, between and within countries and regions. Prevention is generally far more cost-effective and environmentally beneficial than measures taken following introduction and establishment of an invasive alien species (CBD, 2002). | IPBES 2023 |
| Risk analysis (assessment / management / communication) | (1) the assessment of the consequences of the introduction and of the likelihood of establishment of an alien species using science-based information (i.e., risk assessment), and (2) to the identification of measures that can be implemented to reduce or manage these risks (i.e., risk management), taking into account socio-economic and cultural considerations. | CBD COP Decision VI/23 |
| Citizen science/community science | Citizen science refers to research collaborations in which volunteers and scientists partner to answer real-world questions. | IPBES 2023 |

# Enclosure 2

## Resources to support the develomment and implementation of actions towards Target 6

The present enclosure contains a list of resources that can support Parties and other stakeholders with the development and implementation of actions towards the Kunming-Montreal Global Biodiversity Framework target 6 on invasive alien species.
The resources are grouped into four categories, one on baseline information and the others on the different elements of target 6:

### 1. Non-exhaustive list of resources for compiling baseline information and prioritizing invasive alien species, pathways of introduction, and sites

**Data sources on invasive alien species, their impacts and pathways of introduction**

- CABI Horizon Scanning Tool. A decision support aid that helps identify and categorize species that might enter a particular geographic area from another geographic area. https://www.cabi.org/HorizonScanningTool/
- CABI Invasive Species Compendium. Provides detailed coverage of invasive pests, plants, fungi and animal diseases to help support decision-making in invasive species management worldwide. https://www.cabidigitallibrary.org/product/QI
- CABI Pest Risk Analysis tool. A decision-support tool that presents scientific information from the CABI Compendium to aid the selection of appropriate measures for reducing risk of pest introduction and facilitating the safe movement of plants and plant products. https://www.cabi.org/PRA-Tool/signin?returnUrl=%2Fpra-tool%2F

- Costello, M.J., Ahyong, S., Bieler, R., *et al.* (2015). World Register of Introduced Marine Species (WRIMS). http://www.marinespecies.org/introduced
- FAO Invasive and introduced tree species database. The database provides summarized information about those forest tree species that have been reported naturalized or invasive in at least one country or territory. https://www.fao.org/forestry-fao/24107/en/
- Global Biodiversity Information Facility – GBIF. An international network and data infrastructure that enables data-holding institutions to share information about where and when species have been recorded. https://www.gbif.org/
- Global Register of Introduced and Invasive Species – GRIIS. Validated country checklists of alien and invasive alien species. https://griis.org/
- Invacost – Project that has produced a database with estimated the economic costs associated with biological invasions worldwide. https://invacost.fr/en/accueil/
- IUCN Global Invasive Species Database – GISD. A source of information about alien and invasive alien species that negatively impact biodiversity, including on their impacts, distribution, pathway of introduction, and management. GISD also includes EICAT assessments made at the global scale. https://www.iucngisd.org/gisd/
- IUCN Red List of Threatened Species™. Comprehensive information source on the global extinction risk status of animal, fungus and plant species. It currently lists over 160,000 species, with information on the distribution, habitat and ecology, and threats, including from invasive alien species. https://www.iucnredlist.org/
- Plants of the World Online. Provides information on the taxonomy, identification, images, distribution, traits, threat status, molecular phylogenies and uses of vascular plants worldwide. https://powo.science.kew.org/

**Non-exhaustive list of data sources on potential sensitive sites for biodiversity**

- Protected planet. A source of data on protected areas and other effective area-based conservation measures (OECMs). https://www.protectedplanet.net/en
- World database on Key Biodiversity Areas. Provides access to information on the worlds Key Biodiversity Areas, which are sites that support critical populations of the world's threatened species. https://www.keybiodiversityareas.org/

**Non-exhaustive list of resources for identifying and prioritizing pathways of introduction**

- CBD SBSTTA/18/9/Add.1. Pathways of introduction of invasive species, their prioritization and management. https://www.cbd.int/doc/meetings/sbstta/sbstta-18/official/sbstta-18-09-add1-en.pdf
- Dawson, J., Oppel, S., Cuthbert, R.J., *et al.* (2014). Prioritizing islands for the eradication of invasive vertebrates in the United Kingdom overseas territories. *Conservation Biology*, Vol. 29, Issue 1 (August) https://doi.org/10.1111/cobi.12347
- European Commission, Directorate-General for Environment, Harrower, Scalera, Pagad *et al.* 2020. Guidance for interpretation of the CBD categories of pathways for the introduction of invasive alien species. *Publications Office*. https://data.europa.eu/doi/10.2779/6172
- NOBANIS. (2015). Invasive alien species pathway analysis and horizon scanning for countries in Northern Europe. *Nordic Council of Ministers, Copenhagen*. doi:10.6027/TN2015-517
- Rabitsch, W., Heger, T., Jeschke, J., *et al.* (2018). Analysis and prioritisation of pathways of unintentional introduction and spread of invasive alien species in Germany in accordance with Regulation (EU) 1143/2014. https://www.bfn.de/en/publications/bfn-schriften/bfn-schriften-490-analysis-and-prioritisation-pathways-unintentional

**Non-Exhaustive list of additional resources to support prioritization of invasive alien species (incl. risk assessment and risk management)**

- Bacher, S., Blackburn, T.M., Essl, F., *et al.* (2017). Socio-Economic Impact Classification of Alien Taxa - SEICAT. *Methods in Ecology and Evolution*, Vol.9, Issue 1 (July). A standardised method for classifying alien taxa in terms of the magnitude of their impacts on human well-being, and is designed to align closely with EICAT. https://doi.org/10.1111/2041-210X.12844
- Booy, O., Mill, A.C., Roy, H.E., *et al.* (2017). Risk management to prioritise the eradication of new and emerging invasive non-native species. *Biological Invasions*, Vol. 19 (May). https://doi.org/10.1007/s10530-017-1451-z
- ISPM 11. (2019). Pest Risk Analysis for quarantine pests. This is an international standard to assess the risk of pests or alien plants becoming invasive. https://www.ippc.int/en/publications/639/
- IUCN (2020). IUCN EICAT Categories and Criteria. The Environmental Impact Classification for Alien Taxa First edition. Gland, Switzerland and Cambridge, UK: IUCN.. The IUCN global standard for measuring the magnitude of environmental impacts caused by alien species. This can be applied at global, regional or national scale to support prioritisation of invasive alien species. https://www.iucn.org/resources/conservation-tool/environmental-impact-classification-alien-taxa
- Kenis, M., Agboyi, L.K., Adu-Acheampong, R., *et al.* (2022). Horizon scanning for prioritising invasive alien species with potential to threaten agriculture and biodiversity in Ghana. *NeoBiota*, Vol. 71 (February) https://doi.org/10.3897/neobiota.71.72577
- Kumschick, S., Wilson, J.R.U., and Foxcroft, L.C.. (2020). A framework to support alien species regulation: the Risk Analysis for Alien Taxa (RAAT). *NeoBiota*, Vol. 62 (October). https://doi.org/10.3897/neobiota.62.51031
- McGeogh, M.A., Genovesi, P., Bellingham, P.J., *et al.* (2016). Prioritising species, pathways, and sites to achieve conservation targets for biological invasion. *Biological Invasions*, Vol. 18 (November) https://doi.org/10.1007/s10530-015-1013-1
- Roy, H.E., Rabitsch, W., Scalera, R., *et al.* (2017). Developing a framework of minimum standards for the risk assessment of alien species. *Journal of Applied Ecology*, Vol. 55, Issue 2 (March) https://doi.org/10.1111/1365-2664.13025
- USFWS – Ecological Risk Screening Summaries. https://www.fws.gov/story/ecological-risk-screening-summaries
- WOAH – Import Risk Analysis for assessing the disease risks associated with the importation of animals, animal products, etc. https://www.woah.org/fileadmin/Home/eng/Health_standards/tahc/2018/en_chapitre_import_risk_analysis.htm#:~:text=The%20process%20of%20import%20risk,health%20in%20the%20exporting%20country.

**Examples of regional and global networks with resources**

- Caribbean Invasive Alien Species Network is a collaboration of national, regional and international organisations engaged in the field of invasive alien species control, whose objective is to reduce the potential threat posed by IAS to health and livelihoods; to intra-regional and international trade; and to the Caribbean's endemic biodiversity and priceless ecosystems. https://caribbeaninvasives.org/
- European Alien Species Information Network (EASIN). EASIN facilitates the exploration of existing alien species information from a variety of distributed information sources through web tools and interoperable web services, compliant with internationally recognized standards. https://easin.jrc.ec.europa.eu/easin#

- European Network on Invasive Alien Species (NOBANIS). NOBANIS is a gateway to information on alien and invasive species in North and Central Europe. https://www.nobanis.org/
- INVASIVESNET International Association for Open Knowledge on Invasive Alien Species (INVASIVESNET) is a non-profit, non-governmental organization open to individuals and organizations involved in research, management and exchange of knowledge on invasive species. https://www.invasivesnet.org/
- IUCN SSC Invasive Species Specialist Group (ISSG). The ISSG promotes and facilitates the exchange of invasive species information and knowledge across the globe and ensures the linkage between knowledge, practice and policy so that decision making is informed. The two core activity areas of the ISSG are policy and technical advice, and information exchange through our online resources and tools and through networking. https://www.iucn.org/our-union/commissions/group/iucn-ssc-invasive-species-specialist-group & https://www.iucn.org/our-work/topic/invasive-alien-species
- NEOBIOTA European Group on Biological Invasions. NEOBIOTA is the European Group on Biological Invasions. It is a consortium of scientists and environmental managers aiming to enhance integration of invasion research and strengthen approaches to counteract negative effects of introduced organisms on biodiversity, ecosystem services and human health. NEOBIOTA addresses theoretical and applied aspects of biological invasions, but also aims at educating the public and consulting with policy makers. https://www.neobiota.eu/
- North American Invasive Species Network (NAISN). NAISN is a consortium that uses a coordinated network to advance science-based understanding and enhance management of non-native invasive species. https://www.naisn.org/
- Pacific Invasive Learning Network (PILN). PILN connects Pacific professionals and practitioners to share knowledge, expertise, tools, and ideas that are vital to managing invasive species effectively. https://www.sprep.org/invasive-species-management-in-the-pacific/piln

## 2. Non- exhaustive list of resources for managing pathways of introduction

- Barros, A., Shackleton, R., Rew, L., *et al.* (2022). Tourism, recreation and biological invasions. *CABI*. Includes information on how tourism-related infrastructure and activities promote biological invasions, including key pathways for non-native invasive species introductions. https://www.cabidigitallibrary.org/doi/book/10.1079/9781800620544.0000
- CBD COP Decision XII/16. Guidance on devising and implementing measures to address the risks associated with the introduction of alien species as pets, aquarium and terrarium species, and as live bait and live food. https://www.cbd.int/doc/decisions/cop-12/cop-12-dec-16-en.pdf
- ICAO. (2007). Air transport remains a major pathway for invasive alien species. Document highlighting the role of air transportation as a pathway for invasive alien species. https://www.icao.int/publications/journalsreports/2007/6201_en.pdf
- IMO. (2023). Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species. Intended to provide a globally consistent approach to the management of biofouling, which is the accumulation of various aquatic organisms on hulls of ship. https://www.imo.org/en/OurWork/Environment/Pages/Biofouling.aspx
- IMO. Guidance documents on ballast water management. Series of guidelines to support governments and stakeholders on uniform and effective implementation of BWM Convention. https://www.imo.org/en/OurWork/Environment/Pages/BWMConventionandGuidelines.aspx
- IMO/ILO/UNECE Code of Practice for Packing of Cargo Transport Units. The CTU Code, inter alia, introduces a duty to ensure that cargo transport units, including shipping containers, are not infested with plants, plant products, insects or other animals. https://www.imo.org/en/OurWork/Safety/Pages/CTU-Code.aspx

- IPPC E-commerce Portal. A guide to managing the pest risk posed by goods ordered online and distributed through postal and courier pathways. https://www.ippc.int/en/core-activities/capacity-development/e-commerce/
- IPPC International Standards for Phytosanitary Measures (ISPMS). As of April 2024, there are 46 ISPMS, 33 diagnostic protocols, and 46 phytosanitary treatments that aim to protect agriculture and food security, and the environment and biodiversity from plant pests and diseases. These include on the intentional movement of: seeds; wood; growing media in association with plants for planting; and used vehicles, machinery and equipment. https://www.ippc.int/en/core-activities/standards-setting/ispms/#:~:text=International%20Standards%20for%20Phytosanitary%20Measures,ISPM)%20was%20adopted%20in%201993.
- IPPC Sea container supply chains and cleanliness. This guidance identifies the key parties involved in the international container supply chains and describes their roles and responsibilities for minimizing visible pest contamination of sea containers and their cargoes, and best practices they may follow to meet that objective. https://www.ippc.int/en/core-activities/capacity-development/sea-containers/
- Secretariat of the Convention on Biological Diversity. 2010. Pets, Aquarium, and Terrarium Species: Best Practices for Addressing Risks to Biodiversity. Montreal, SCBD, Technical Series No. 48. https://www.cbd.int/doc/publications/cbd-ts-48-en.pdf
- WOAH Standards, Guidelines, and Recommendations. Includes the Terrestrial and Aquatic Animal Health codes that provide standards for the improvement of animal health and welfare and veterinary public health worldwide, including through standards for safe international trade. https://www.woah.org/en/what-we-do/publications/

## 3. Non-exhaustive list of resources for preventing the introduction and establishment of alien species

- FAO. (2018). International Standard for Phytosanitary Measures 6. Surveillance. *Food and Agriculture Organization of the United Nations*. http://www.fao.org/documents/card/en/c/7985f320-a606-47f9-9f0b-9dfa5a2e1622
- IUCN. (2018). Guidelines for invasive species planning and management on islands. Cambridge, UK and Gland, Switzerland. *IUCN*. These guidelines are designed to assist anyone planning and programming the management of invasive species on islands. https://doi.org/10.2305/IUCN.CH.2018.15.en
- Sankaran, K., Schwindt, E., Sheppard, A.W., *et al.* (2023). Chapter 5: Management; challenges, opportunities and lessons learned. In: Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H. E., Pauchard, A., Stoett, P., and Renard Truong, T. (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430733

## 4. Non-exhaustive list of resources for the eradication and control of invasive alien species

- FAO. (2011). Sustainable Forest Management (SFM) Toolbox. Includes decision-making guide for invasive species program managers or the document alien invasive species: impacts on forests and forestry (Moore, B. 2005). https://www.fao.org/sustainable-forest-management/toolbox/tools/tool-detail/en/c/230818/ and https://www.fao.org/4/j6854e/j6854e00.htm
- Island Conservation. Database of Island Invasive Species Eradications (DIISE). Attempts to compile all historical and current invasive vertebrate eradication projects on islands. http://diise.islandconservation.org/

- Katsanevakis, S. (2022). Management Options for Marine IAS. Technical note prepared by IUCN for the European Commission. The report provides a global review of the scientific literature on the effectiveness of management of marine IAS, analyses globally applied management options for marine invasive species, identifies best practices and success stories, and reviews constraints to managing marine IAS. https://circabc.europa.eu/ui/group/4cd6cb36-b0f1-4db4-915e-65cd29067f49/library/1e85f0e4-9df0-4008-915b-39315a21dd37/details
- Sankaran, K., Schwindt, E., Sheppard, A.W., *et al.* (2023). Chapter 5: Management; challenges, opportunities and lessons learned. In: Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H. E., Pauchard, A., Stoett, P., and Renard Truong, T. (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430733
- Shackleton, R.T., Adriaens, T., Brundu, G., *et al.* (2019). Stakeholder engagement in the study and management of invasive alien species. *Journal of Environmental Management*, Vol. 229 (January) https://doi.org/10.1016/j.jenvman.2018.04.044
- Sheppard, A.W., Paynter, Q., Mason, P., *et al.* (2019). IUCN SSC Invasive Species Specialist Group. The Application of Biological Control for the Management of Established Invasive Alien Species Causing Environmental Impacts. The Secretariat of the Convention on Biological Diversity Technical Series No. 91. Montreal, Canada 88 pages. The document provides detailed technical information on the application of classical biological control, as well as the track record and case studies of past successful applications, including evidence of non-target impacts. https://www.cbd.int/doc/publications/cbd-ts-91-en.pdf
- University of Cambridge. Conservation evidence. A free information resource designed to support decisions about how to maintain and restore global biodiversity. Presents Summarise evidence from the scientific literature (studies) about the effects of conservation actions such as methods of habitat or species management. https://www.conservationevidence.com/

# Enclosure 3

## Guidance for the development and implementation of a National Invasive Speies Strategy and Action Plan

## I. Introduction

The Convention on Biological Diversity through Article 6[105] on general measures for conservation and sustainable use indicates that each contracting Party shall, in accordance with its particular conditions and capabilities:

(a) Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes which shall reflect, inter alia, the measures set out in this Convention relevant to the Contracting Party concerned;

(b) Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies.

Article 6 creates an obligation for national biodiversity planning. A national strategy will reflect how the country intends to fulfil the objectives of the Convention in light of specific national circumstances, and the related action plans will constitute the sequence of steps to be taken to meet these goals. Countries response to Article 6 are National Biodiversity Strategies and Action Plans (NBSAPs).

In the Kunming Montreal Global Biodiversity Framework, on its section B also indicate that the framework is action- and results-oriented and aims to guide and promote, at all levels, the revision,

[105] https://www.cbd.int/convention/articles/default.shtml?a=cbd-06

development, updating, and implementation of policies, goals, targets, and national biodiversity strategies and actions plans, and to facilitate the monitoring and review of progress at all levels in a more transparent and responsible manner.

Based on the above, a National Invasive Species Strategy and Action Plan (NISSAP), can complement the objectives set on an NBSAP, and provide more detailed information to guide national and/or regional actions towards mitigating the threats of invasive Alien Species (IAS) and reducing their pressure on biological diversity.

This document presents guidance for the development and implementation of a NISSAP. It builds on the Toolkit for the implementation of Target 6 but can be used as a standalone document.

# II. The National Invasive Speies Strategy and Action Plan process

A NISSAP is a formal strategic document that sets out the priority actions, along with timelines, responsibilities and budgetary needs, that need to be taken to address threats posed by IAS. However, the process of developing a NISSAP is as important as ensuring that the priority actions are contained within it. To ensure that the actions and policies are given the greatest chance of success, a cross-sectoral collaborative approach needs to be taken from the outset, and the decision on what to include needs to be informed by the best available evidence. In addition, the implementation of actions included within a NISSAP need to adapt to changing circumstances and new evidence.

This document aims to address these important aspects by setting out a strategic framework on how to develop a NISSAP, what actions can be included within it, and how to adapt implementation. Figure I presents the NISSAP development and implementation framework which consists of four interconnected steps supported by additional cross-cutting actions and enablers. Figure II details the elements that can be considered under each step, which are discussed individually in this document. While this guidance identifies and describes the key elements of a NISSAP and its development, i.e. what can be done, it does not go into detail on how the actions can be implemented. More information on the 'how to' can be found in the citations and links provided in the footnotes.

It is important to stress that not all the elements presented in the framework need to be developed or implemented for an effective NISSAP. The levels of engagement, data mobilisation and actions taken need to reflect national circumstances. Any action taken, no matter how small can result in significant benefits.

Figure I

**NISSAP development and implementation framework which consists of four interconnected steps supported by additional cross-cutting actions and enablers**

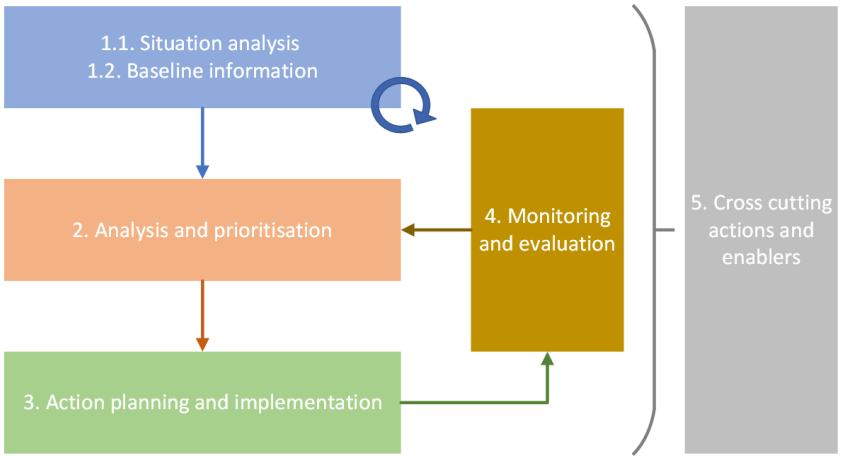
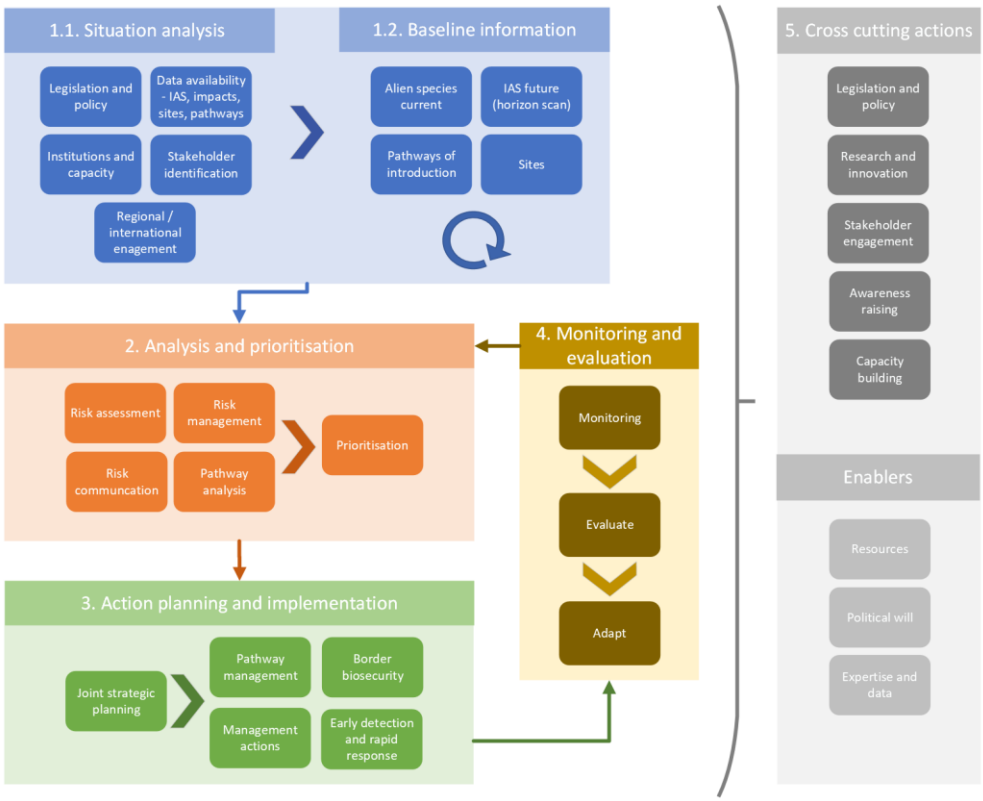


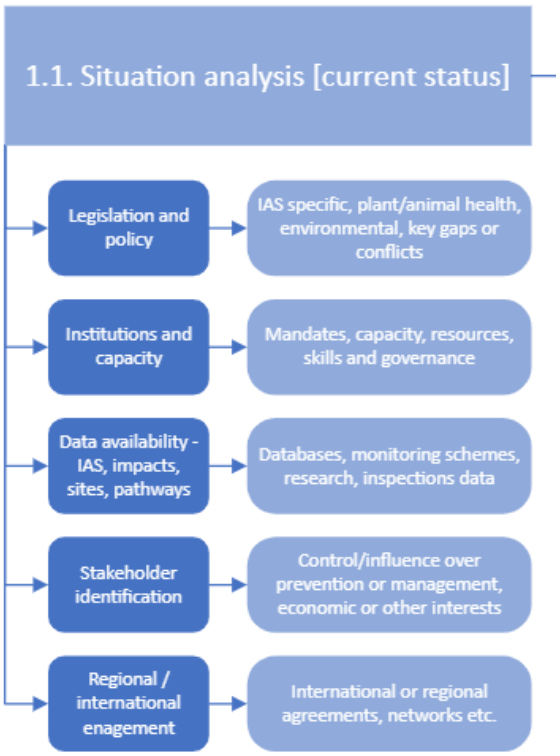
Figure II
**National Invasive Species Strategy and Action Plan** framework with the individual elements that can be considered under each step. Each element is discussed separately within this guidance




## Step 1.1. Situation analysis

Before developing a NISSAP it is important to understand the current situation of actions taken to address IAS at a national level. A situation analysis will support the identification of existing capacity and actions, but also the gaps and needs. Engagement across government ministries (e.g. fisheries, forestry, agriculture, environment, trade, customs and transport) may be needed in order to undertake a situation analysis (Figure III).

Figure III
**Step 1.1 elements for undertaking a situation analysis to identify the current status of related measures to invasive alien species**




### i. Legislation and policy

Reviewing the current status of laws and policies related to IAS will help identify gaps and conflicts between related policies and facilitate discussion among relevant ministries.

Relevant existing laws and policies may not necessary be specific to IAS, but may focus on broader environmental protection, wildlife management, plant/animal health, or other agriculture or aquaculture issues. In some cases, voluntary codes of conduct may have been adopted and these can also provide a useful reference for informing understanding of the current situation.

Once legislations and policies are identified, key gaps and conflicts between these policies can be identified and then addressed in the action plan.

### ii. Institutions and capacity

Mapping the relevant government institutions, including ministries, agencies and competent authorities, that are or could be relevant to IAS, will help understand existing capacity, responsibility and gaps. The scope should not be limited to government institutions that have jurisdiction over existing IAS related policies but should also include those that could in the future play a role in the prevention of the introduction and establishment of alien species, or the management of IAS.

Mapping of institutional mandates, capacity, resources, skills and governance will facilitate the identification of gaps and potential synergies between the institutions in implementing actions within the NISSAP.

### iii. Data availability

Before undertaking work to develop baseline information (see Step 1.2) it is important to understand what data and other resources are already available. Data are fundamental for identifying and prioritising IAS, pathways of introduction, sites and management actions as required for meeting

Target 6. It also enables the establishment of baselines so that progress towards targets and goals, or the effectiveness of management interventions can be monitored.

Collating an inventory of available data and resources could include checklists on alien species presence, databases on threatened native species and impacts from IAS, field guides, biodiversity reports, monitoring schemes, research, and inspections data on IAS. An inventory of data and resources will help identify gaps in knowledge that can be addressed in Step 1.2 Baseline information.

**iv. Stakeholder identification**

Effective management of IAS not only requires a whole-of-government (see institutional capacity above) but also a whole-of-society approach. Engagement and collaboration with non-government stakeholders and indigenous peoples and local communities will improve outcomes of management actions. Identification of stakeholders and rightsholders can be achieved by listing those groups who may be positively or negatively affected by IAS, or who may be able to play a role in their prevention and management.

The perception of some IAS may differ across stakeholder groups. These can be 'conflict' species that have both negative and positive impacts, such as cultural or economic value, and are therefore challenging to manage. Identifying potential conflicts at this early stage can facilitate engagement and improve the likelihood of management success.

**v. Regional / international engagement**

Regional and international cooperation helps strengthen action to address IAS, and especially for the prevention of introduction through collaborative actions.

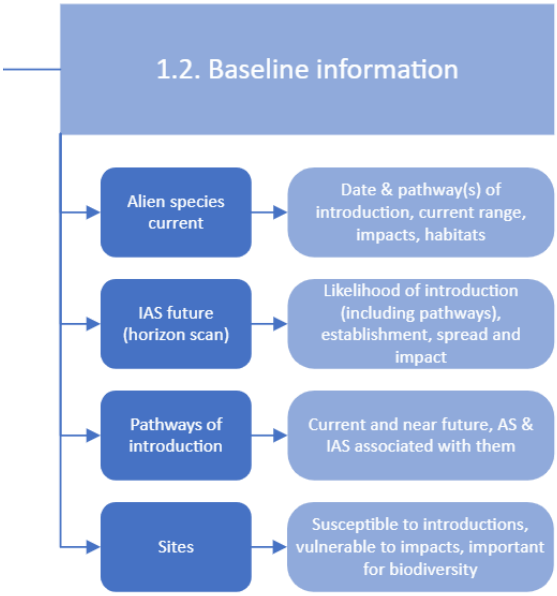
Knowing which regional and international agreements relevant for IAS are ratified, and which networks are engaged with will help in the development of actions that may be best addressed at a bilaterial, regional or global level.

The Convention on Biological Diversity for instance, works with several other international and standard setting organizations through the Inter-agency Liaison Group on IAS.

## Step 1.2. Baseline information

Compiling available baseline information (see Figure IV), on alien and IAS, pathways of introductions, and sites, will support the decision-making process to develop a NISSAP. Any information relating to which species are present, where they are, if they are spreading and the impacts they are having, will be useful for prioritising (Step 2) and guiding actions (Step 3), and for reporting and evaluating progress (Step 4) towards T6. Recognising knowledge gaps in the baseline data is important but shouldn't stop action being taken. Horizon scanning can provide a useful assessment of what future threats to be aware of and knowledge of sites that are susceptible or vulnerable to invasion may help guide actions. Baseline information should be maintained and updated on a regular basis if possible.

Figure IV
**Elements for baseline information considered in Step 1.2 that can be used for analysis and prioritisation in Step 2, and to inform action planning and implementation (Step 3)**




### i. Species list of current alien species

A list of currently established alien species is the foundation of the baseline information. Species lists can be collated through a variety of approaches including through access to existing open online information systems. Information can be added over time and does not need to be 'complete' to be useful for further work.

A list of IAS that are currently known or suspected to have impacts upon nature in the country is usually the most accessible information with which to start. This can be extended to include a longer list of alien species known to have been recorded in the country. As a starting point there are freely available global and regional databases including the Global Register of Introduced and Invasive Species - GRIIS[106] which provides national checklists of alien species. These can be supplemented by additional information from a variety of sources, including reports, surveys and consultation with local experts. See Box 1 for suggested key information to be included.

**Box 1. Invasive alien species lists should include:**

- Scientific names to facilitate access to information in other data systems, which may include species identification, impacts and management.
- Common names, where available, including those used locally, to improve access to information and ease of communication.
- Higher taxonomy or 'groups' of species (e.g. flowering plants) to categorize species. There are global datasets to support this process, e.g. GBIF, and Plants of the World.

Adding other information on alien species, such as evidence of impacts,[107] can help with the prioritisation of alien species, pathways of introduction and management actions (Step 2).

[106] The Global Register of Introduced and Invasive Species - GRIIS. Produced by the IUCN SSC Invasive Species Specialist Group (ISSG) within the framework of activities of the Global Invasive Alien Species Information Partnership (GIASIP) https://griis.org/ (also available via GBIF https://doi.org/10.15468/puy8bx)

[107] Classifying alien species in terms of the magnitude of their environmental impacts can be done by applying the IUCN Environmental Impact Classification for Alien Taxa - EICAT Categories and Criteria

### ii. Invasive alien species future/horizon scan

A horizon scanning approach can be used to identify and prioritise alien species that are likely to arrive in the near future. This information will support the development of measures to prevent their introduction. A horizon scan is usually undertaken using a structured process involving expert elicitation and consensus-building and can still be applied where there is a lack of evidence.

A horizon scan does not need comprehensive evidence and data, nor access to lots of expertise to undertake. The fundamentals, which are taken from the approach developed by Roy *et al*. (2014) and Roy *et al*. (2018) [108] are:

- Compile a list of species not yet established in the territory of interest which have the potential to arrive within the foreseeable future.
- Assigning plausible pathways of introduction for the species included on the list.
- Score the species according to likelihood of arrival, establishment, and spread, and the potential impact upon biodiversity and ecosystem services.
- Ranking the species.
- Consideration of management actions

Horizon scanning may be undertaken for all IAS or for groups of species based on taxonomy or environment. When scoring it is useful to consider the previous invasion history, especially of neighbouring or geographically/ climatically similar regions. Tools can help categorise impacts such as EICAT[109] for Environmental and SEICAT[110] for Socio-economic and human health impacts.

### iii. Pathways of introduction

Identifying the pathways of introduction of past and future alien species introductions into the territory is the first step towards developing pathway action plans. Ideally this information will be collated during the generation of the species lists and will use the standardised pathway terminology and classification produced under the CBD.[111] Using this framework will support integration with work that has been done by other countries, regions and globally to identify, prioritise and manage specific pathways.

The pathways of introduction should be assigned to as many species as possible in the list of currently established alien species and the horizon scan list. It is likely that the pathway of introduction for many species is not known for certain. In addition, more than one pathway can be assigned to a species, therefore choosing the relevant pathways to assign can be challenging, however additional guidance[112] has been produced to support this process which includes decision tree flow charts, and species examples for each pathway.

Once the pathways have been allocated to the species within the list, it will be possible to assess patterns and trends in pathways of introduction**.** This will allow for the identification of those

https://doi.org/10.2305/IUCN.CH.2020.05.en. Note that all global EICAT assessments are made available on the IUCN Global Invasive Species Database. https://www.iucngisd.org/gisd/

[108] Roy, H.E., Peyton, J., Aldridge, D.C., *et al.* (2014). Horizon scanning for invasive alien species with the potential to threaten biodiversity in Great Britain. Global Change Biology; Vol. 20, Issue 12 (December) https://doi.org/10.1111/gcb.12603; Roy, H.E,, Bacher, S., Essl, F., *et al.* (2019). Developing a list of invasive alien species likely to threaten biodiversity and ecosystems in the European Union. Global Change Biology; Vol 25, Issue 3 (March) https://doi.org/10.1111/gcb.14527

[109] Classifying alien species in terms of the magnitude of their environmental impacts can be done by applying the IUCN Environmental Impact Classification for Alien Taxa - EICAT Categories and Criteria https://doi.org/10.2305/IUCN.CH.2020.05.en.

[110] Bacher, S., Blackburn, T.M., Essl, F., *et al.* (2017). Socio-economic impact classification of alien taxa (SEICAT). Methods in Ecol and Evol., Vol. 9, Issue 1 (January) https://doi.org/10.1111/2041-210X.12844

[111] CBD SBSTTA/18/9/Add.1. Pathways of introduction of invasive species, their prioritization and management. https://www.cbd.int/doc/meetings/sbstta/sbstta-18/official/sbstta-18-09-add1-en.pdf

[112] European Commission, Directorate-General for Environment, Harrower, C., Scalera, R., Pagad, S. *et al.* (2020). *Guidance for interpretation of the CBD categories of pathways for the introduction of invasive alien species*, Publications Office, 2020. https://data.europa.eu/doi/10.2779/6172

pathways that have led to the introduction of alien species in the past, and those that are relevant for future introductions, as they may be different.

Consideration of pathways of introduction into a territory could be extended to include the pathways of spread, as many alien species may be introduced by one pathway (e.g. aquarium trade) but then spread via another (e.g. biofouling on boats). Pathway of spread information is useful for prioritization of management actions that aim to contain the spread of IAS.

**iv. Sites**

Site-based management is an important approach to eliminate or reduce impacts from IAS and requires identifying where the important or priority sites are within the territory and what actions are applicable. In general, there are two categories of sites that require different actions;[113] i) *susceptible* sites that are at high risk to introductions and establishments of alien species, and ii) *sensitive* sites that are vulnerable to the greatest impacts from IAS.

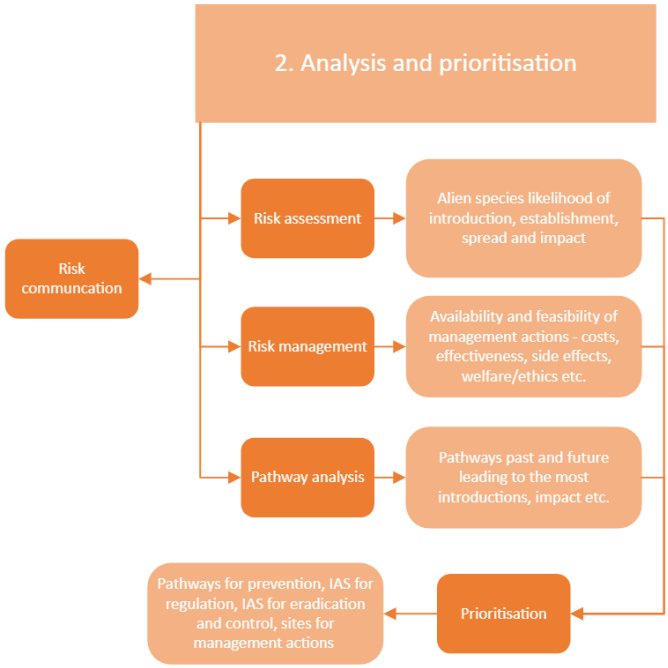
This site-based approach could be broadened out to cover a wider range of 'values'**.** For example, priority sites could be areas important for ecosystem services, food security, cultural importance or tourism. Consideration of site-based management (e.g. removal of IAS populations) and ecosystem-based management (e.g. restoration of river flow regimes) can also help inform the selection of sensitive sites. There may also be sites already prioritised for management by rightsholders or stakeholders, e.g. by Indigenous Peoples. These sites may have existing capacity to deploy management actions and can be identified within the site-based approach.

## Step 2. Analysis and prioritization

To inform decisions on effective resource allocation and actions, there are a number of elements that need to be considered and prioritised (figure V). Building on the baseline information gathered in Step 1.2, analysis of the risks that species pose (establishment, spread, impact) and identification of the most important pathways of introduction and priority sites should be done in a structured way.

[113] McGeogh, M.A., Genovesi, P., Bellingham, P.J, *et al.* (2016). Prioritising species, pathways, and sites to achieve conservation targets for biological invasion. *Biological Invasions,* Vol. 18 (November) https://doi.org/10.1007/s10530-015-1013-1

Figure V
**Step 2 describes the process of analysis and prioritization based on the data collected in Step 1, to support decision making and implementation as described in Step 3**




This process includes risk analysis of species, which is a combination of risk assessment and risk management, associated with risk communication, and analysis of pathways, which enables prioritization.

### i. Risk assessment

Risk assessment is a systematic process used to evaluate the potential for an alien species to be introduced, establish, spread and cause negative impacts in a defined area. They provide an important evidence-base for underpinning policy and legislation and specifically provide crucial evidence to effectively allocate resources for conservation and, with effective communication, increased support from stakeholders and the public.

At its simplest, risk assessment involves considering the separate steps within the biological invasion process:

- Likelihood of entry / introduction
- Likelihood of establishment
- Rate of spread
- Magnitude of impact

Species are typically scored for each step and then an overall risk is determined based on this evaluation. Scoring can be done in a semi-quantitative way using guidance criteria and the best available evidence or expert judgements.
Species lists can be screened for known IAS and databases such as the GRIIS[114] and CABI compendium[115] can be used to check if there is an invasion history in a situation comparable to the target area (e.g. similar climate and habitat), which can be used to help evaluation. The evidence base

[114] The Global Register of Introduced and Invasive Species - GRIIS. Produced by the IUCN SSC Invasive Species Specialist Group (ISSG) within the framework of activities of the Global Invasive Alien Species Information Partnership (GIASIP) https://griis.org/ (also available via GBIF https://doi.org/10.15468/puy8bx)
[115] CABI compendium on invasive species https://www.cabidigitallibrary.org/product/qi

for evaluation of risk can be formally assessed using existing impact scoring schemes such as the environmental impact categories set out by the EICAT[116] or use climate matching/habitat suitability systems and models to identify risk of future establishment and spread.[117] Additional criteria could also be included, for example socio-economic[118], and human health impacts.

**ii. Risk management**

Risk management involves making a structured assessment on the availability and feasibility of management actions - costs, effectiveness, side effects, welfare/ethics etc. to eliminate, minimise or mitigate the impacts of IAS. Evaluation of risk management for established species will consider the feasibility of eradication, containment, control etc. while species not yet arrived (horizon scan species) can be evaluated for prevention and contingency planning. Assessment of management feasibility is important to inform decision making on priority species as some high-risk species (determined by risk assessment) may not have a feasible management option. In some cases, it may be obvious when a specific management approach is feasible or not, but decision making should be evidence based.

**iii. Risk communication**

Risk communication is an interactive process that involves communicating evidence about the risk posed by a species or pathway, proposed mitigation measures and uncertainties. Ideally, it is not a one-way provision of information, but instead an interactive process that helps gather and reconcile the views of scientists, stakeholders and politicians. In this way, good risk communication can help improve assessment, build trust in management efforts and address misconceptions.

Uncertainty is an inherent part of alien species risk assessment and the scientific process in general. Communication of uncertainty or confidence in the outcomes of risk assessment is a particular focus of communicating the risk to stakeholders and the public. The understanding and extent of uncertainty is critical to open and transparent communication.

**iv. Pathway analysis**

By analysing pathways of introduction identified in Step 1.2, pathway analysis clarifies which human activities have caused the introduction of alien species. This is achieved through systematic examination of the various routes through which alien and IAS are introduced or spread. The analysis can focus on pre-border (pre-invasion) or post-border pathways of introduction or spread. The analysis can evaluate factors such as the volume of traffic along the pathway, the likelihood of known invasive species being transported along the pathway, the vulnerability of the receiving ecosystems and the potential impact of the alien species if introduced.[119]

**v. Prioritization**

Prioritization processes are a transparent, evidence-based evaluation of multiple species, pathways or sites that provide a basis for decision making. Where resources are limited and uncertainty is high,

[116] Classifying alien species in terms of the magnitude of their environmental impacts can be done by applying the IUCN Environmental Impact Classification for Alien Taxa - EICAT Categories and Criteria https://doi.org/10.2305/IUCN.CH.2020.05.en.

[117] For example, Chai, S-L., Zhang, J., Nixon, A., and Neilson, S. (2016). Using Risk Assessment and Habitat Suitability Models to Prioritise Invasive Species for Management in a Changing Climate. *PLoS ONE*, Vol. 11, Issue 10 (October) https://doi.org/10.1371/journal.pone.0165292

[118] Bacher, S., Blackburn, T.M., Essl, F., *et al.* (2017). Socio-economic impact classification of alien taxa (SEICAT). *Methods in Ecol and Evol.*, Vol. 9, Issue 1 (January) https://doi.org/10.1111/2041-210X.12844

[119] Examples of pathway analysis: NOBANIS. 2015. Invasive alien species pathway analysis and horizon scanning for countries in Northern Europe. Nordic Council of Ministers, Copenhagen. doi:10.6027/TN2015-517; Rabitsch *et al.* 2018. Analysis and prioritisation of pathways of unintentional introduction and spread of invasive alien species in Germany in accordance with Regulation (EU) 1143/2014. https://www.bfn.de/en/publications/bfn-schriften/bfn-schriften-490-analysis-and-prioritisation-pathways-unintentional

a systematic approach is needed to target action to the areas of greatest need and where the greatest benefits can be achieved.

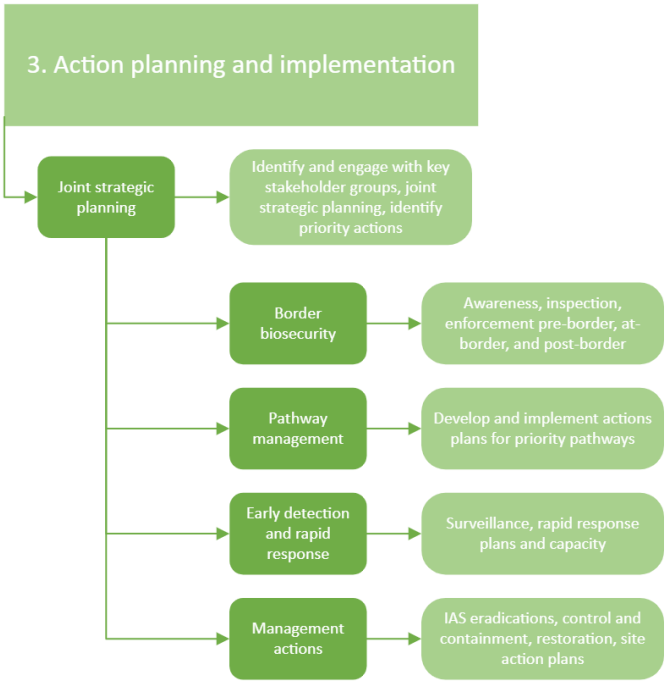
Prioritization should follow the CBD hierarchy (decision 6/23[120]) where prevention is most cost-effective followed by early detection and rapid response, followed by eradication, containment and long-term control measures.

Effective prioritization should be straightforward, in some cases, simple ranking or obvious prioritization may be sufficient and further assessment is not needed but the process should be evidence based to demonstrate that high impact species or pathways are indeed high management priorities.

## Step 3. Action planning and implementation

When all the relevant information has been collated (Step 1.1 and 1.2), analysed and prioritized (Step 2) the appropriate actions can be identified through a consultative process involving relevant stakeholders and formalized in an achievable action plan, i.e. drafting of the NISSAP.
Here we describe the **joint strategic planning** process to develop a NISSAP and outline four elements to consider when planning actions to **prevent the introduction and establishment of new alien species** or to **remove, minimize, or mitigate the impacts from already established IAS** (figure VI). The NISSAP should be a dynamic document that enables adaptive management approaches, a regular review process will allow monitoring of action actions and evaluation of progress to inform updates to actions through time (see Step 4).

Figure VI
**Elements included in Step 3 (action planning and implementation)**




### i. Joint strategic planning to produce a NISSAP

A joint strategic planning approach is a multi-stakeholder process that aims to develop an integrated, coordinated and achievable plan of action.

[120] CBD/COP/DEC/6/23

It is important that **key institutions with responsibility for implementing actions targeting impacts from IAS are engaged with at the start of the action planning process.** Stakeholders that have influence over the implementation of possible actions, and those that may be positively or negatively impacted by the should be included. These stakeholders should have been identified in Step 1.1. situation analysis.

How the engagement is undertaken, and the actions are agreed can depend upon many different factors, including availability of resources and time, cultural practices, or existing planning processes.[121] A relatively simple approach involves the running of one or more stakeholder engagement workshops to agree priority actions, responsibilities, time frames and budget needs.

A *strategy* document will set out the overarching goals that need to be achieved, each with one or more objectives that detail what needs to happen to meet that goal. The *action plan* should define the specific actions that need to be implemented in order to attain the objective. Each action should be 'SMART' (Specific, Measurable, Assigned to someone, Resourced, and Time-limited).

A NISC can comprise of experts from across different government authorities and key stakeholder groups, with an individual or institution taking the coordination responsibility. It should have access to technical and scientific support, and effective communication channels to relevant decision makers.
Finally, it may be useful to support political decision-making processes to incorporate economic principles, so that the benefits from actions taken on IAS are not just presented in biodiversity gains but also economic, and public health.

**ii. Actions - Pathway management**

Pathway management aims to prevent the invasion of alien species by managing the pathway(s) prioritised (see Step 2). These measures can be captured under the NISSAP, or if deemed necessary can be expanded into more detail and take the form of a specific Pathway Action Plan (PAP). When developing PAPs, the following should be considered:[122]

- Understanding the pathway. Consider origins and transit routes, any vectors associated with it (e.g. vehicles, goods, containers, luggage), points of entry (e.g. airports, seaports, post-border destination points) and, if relevant, points of release or escape (e.g. from gardens, wildlife collections, deliberate planting).
- Identify relevant stakeholders and key actors. For example, importers, transport companies, trade associations, hobbyists, government stakeholders (border officials, etc), general public, etc.
- Working with relevant stakeholders:
    - Identify the aim and objectives of the pathway action plan in order to reduce risk of invasion.
    - Determine the key actions that need to be taken to achieve these aims, who will deliver them and by when.
    - Consider aims and actions that include:
        - Awareness raising and behaviour change.
        - Methods to minimise contamination of goods, vehicles, equipment, etc.
        - Appropriate checks at the border and / or at other points along the pathway
        - Codes of practice and or regulation.

Due to the international nature of pathways of introduction, collaboration at a regional or global level will support their management. There are existing international agreements that address some of the

[121] For example, FAO Facilitating effective multi-stakeholder processes https://www.fao.org/capacity-development/resources/practical-tools/multi-stakeholder-processes/en/
[122] Scalera, R. and Genovesi, P. (2016). Guidance for governments concerning invasive alien species pathways action plans. T-PVS/Inf (2016) 10 https://rm.coe.int/1680746339

pathways (e.g. The World Trade Organisation SPS agreement,[123] World Organisation for Animal Health (WOAH)[124] and International Plant Protection Convention (IPPC)[125] standards, the Ballast Water Management Convention and IMO guidelines)[126], and the national authorities with the mandates apply the standards they set should be engaged with in the development of pathway management actions. This includes plant and animal health authorities, marine shipping and ports, and trade.

It is beneficial to ensure that IAS that are vectors/hosts of pathogens (or even in some cases are pathogens themselves), are discussed within a One Health framework, so their risks to domestic animal health, plant health, and human health are understood in addition to the risks posed to native biodiversity. This will support the pathway management, and integration with other sectors work.

**iii. Border security**

Effective border security measures (often termed 'biosecurity') are important for preventing the arrival of new species across many pathways of introduction, and can be applied pre-border, at-border, and post-border.

Consideration should also be given to monitoring online commerce, for example for the sale or import of regulated species. In addition to commerce, the exchange of species via peer-to-peer trading platform, forums and social media can be common. Monitoring and intervening online can be challenging and national and international rules must be followed.

**iv. Early detection and rapid response**

When prevention fails or is not possible, early detection and rapid response actions can contain and remove alien species at an early stage of biological invasion.

Surveillance to rapidly detect new IAS is important to ensure the effectiveness of rapid response and eradication and should be implemented for priority susceptible and vulnerable sites. Surveillance systems can be designed to detect many different IAS or can be specific to one or a few IAS selected through horizon scanning and risk assessment (see Steps 1 and 2).

Surveillance can be achieved through repeatable survey methods or can rely on opportunistic reporting by stakeholders including members of the public. Engagement of stakeholders in surveillance requires effective communication to raise awareness and ensure that methods for reporting any species of concern are clear. Reporting can be achieved through a dedicated e-mail account or using social media such as What's App. 'Citizen-science' programmes can be a cost-effective tool for helping collate useful information on IAS, especially for early detection and species distribution mapping.[127] However, it is critical that someone has the responsibility to check the account and provide feedback as necessary while also ensuring that the information is provided to those who can implement action. Online data systems can also be relatively easily established and provide a more efficient and secure way to capture and share relevant information.

In addition, there are many innovative technologies such as smart traps, sensor networks and eDNA that can also be used to support surveillance efforts for early detection.[128] Trained detector dogs have been effectively used to detect IAS in many contexts including at ports of entry or sensitive sites. Earth observation data from satellites and aerial systems, including drones and under water remote

[123] WTO Sanitary and Phytosanitary measures https://www.wto.org/english/tratop_e/sps_e/sps_e.htm
[124] WOAH standards https://www.woah.org/en/what-we-do/standards/
[125] IPPC international Standards for Phytosanitary Measures (ISPMs) https://www.ippc.int/en/core-activities/standards-setting/ispms/
[126] IMO Ballast Water Management Convention https://www.imo.org/en/OurWork/Environment/Pages/BallastWaterManagement.aspx
[127] Pocock, M.J., Adriaens, T., Bertolino, S., *et al.* (2024). Citizen science is a vital partnership for invasive alien species management and research. *iScience*, Vol. 27, Issue 1 (January) https://doi.org/10.1016/j.isci.2023.108623
[128] Martinez, B., Reaser, J.K., Dehgan, A., *et al.* (2020). Technology innovation: advancing capacities for the early detection of and rapid response to invasive species. *Biological invasions*, Vol. 22 (December). https://doi.org/10.1007/s10530-019-02146-y

vehicles, can be used for rapid and repeatable large-scale assessment of areas which in some cases maybe inaccessible for other survey approaches

**v. Site-based management actions**

Undertaking actions that aim to eradicate, contain, or control established IAS populations are the main means of eliminating, minimising or reducing their impacts upon biodiversity and ecosystem services. When planning and undertaking these management measures, there are three broad objectives that should be considered: eradication, containment, control.

When considering management actions for established IAS populations, **eradication should be considered as the first option**. Where eradication is not deemed to be feasible then other management objectives such as **containment or control** to reduce the distribution, spread or impacts should be considered.

When planning management actions, it is important to consider possible non-target effects, and aim to mitigate these where possible and to adapt or change approaches accordingly. For example, this could include damage to native species or habitats due to chemical application, or the increase in other IAS once the targeted IAS has been removed. It is recommended that the potential animal welfare impacts of any management measure are also taken into consideration when choosing which approach to use and through its application.[129]

In addition, taking an adaptive integrated approach where more than one option is used either in parallel or sequence (e.g. mechanical removal followed by herbicide application), can achieve greater success than the application of either option on their own. This approach can also include the use of ecosystem management approaches (e.g. restoring connectivity or flow regimes in a river) alongside actions that directly target the IAS.

## Step 4. Monitoring and evaluation

When developing a NISSAP, it is important to consider that Global Biodiversity Framework has a monitoring framework with an indicator for Target 6, "the rate of invasive alien species establishment",[130] which is the number of IAS that are expected to have established in a new region or country compared with the reference period, based on modelled trends in IAS observations. National targets should be established considering the information required to report on this, such as species lists, new introductions and pathway management strategies and results.

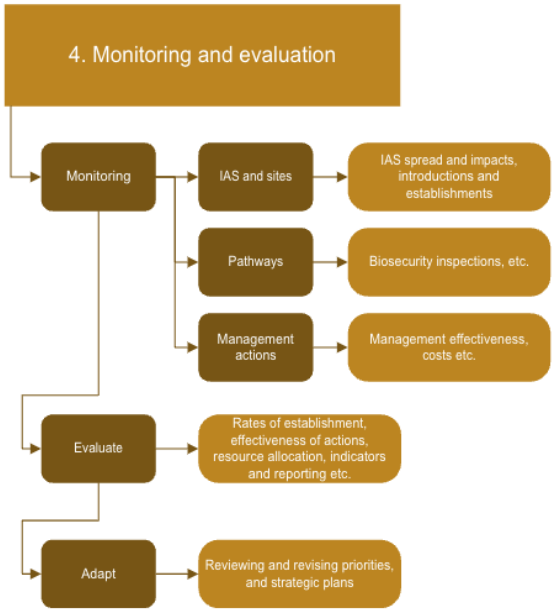
Implementation of the NISSAP should allow for adaptative management through integration of new evidence to update decision making and actions (figure VII). Ongoing monitoring and evaluation will provide updates on the status of biological invasions (e.g. are new species arriving?) and success of any interventions (e.g. which species have been prevented from establishing?) to allow a review of priorities, resource allocation, and adaptation of management methods. Analysis of data from monitoring will also provide trends for indicators on targets and can be used in models to make predictions and can inform future action planning.

[129] Smith, K.G., Nunes, A.L., Aegerter, J., *et al*. (2022). A manual for the management of vertebrate invasive alien species of Union concern, incorporating animal welfare. 1st Edition. Technical report prepared for the European Commission within the framework of the contract no. 07.027746/2019/812504/SER/ENV.D.2 https://easin.jrc.ec.europa.eu/easin/documentation/Codesofconduct .

[130] CBD/SBSTTA/26/INF/14.

Figure VII
**Step 4 describes the process of reviewing and updating data and information on invasive alien species, including evaluating outcomes of management actions**

This step will require prioritized lists of species and pathways (step 2) and management actions (step 3).




### i. Monitoring

Integration of new data into baseline datasets of species occurrence (Step 1) and management (Step 3) is essential to provide up-to-date lists of species and their impacts.

Monitoring of IAS should capture any changes to baseline information that can be attributed to the causes (or drivers) of the biological invasions, resource allocation or management actions, it may also be possible to monitor the benefits through tracking of the conversation status of species and habitats that are threatened by IAS. It is important to keep in mind that the indicator from the monitoring framer of the Kunming Montreal Global Biodiversity Framework should be use for reporting un the progress for target 6.

### ii. Evaluate

Analysis and evaluation of available data will allow tracking of IAS and assessment of the effectiveness of management actions to reduce the magnitude of their impacts. Regular updating of species lists will facilitate evaluation of trends in numbers of species arriving and establishing, including information on likely or known pathway of introduction, and magnitude of impact. Sources of uncertainty, bias and gaps in knowledge should be identified and documented.

The range of **indicators and trends** used to track biological invasions will depend on the quality of data being collected. Indicators do not need to be complex but should consider bias and uncertainty in data availability. **Simple metrics can be determined for species entering, establishing, by pathway and impact severity.** However, the usefulness of these metrics will be dependent greatly on the level of surveillance or monitoring effort and the detectability of the species so ideally these metrics should be standardised when presenting trends through time[131].

[131] McGeoch, M.A., Buba, Y., Arle, E., *et. al*. (2023). Invasion trends: An interpretable measure of change is needed to support policy targets. *Conservation Letters*, Vol. 16, Issue 6 (October) https://doi.org/10.1111/conl.12981

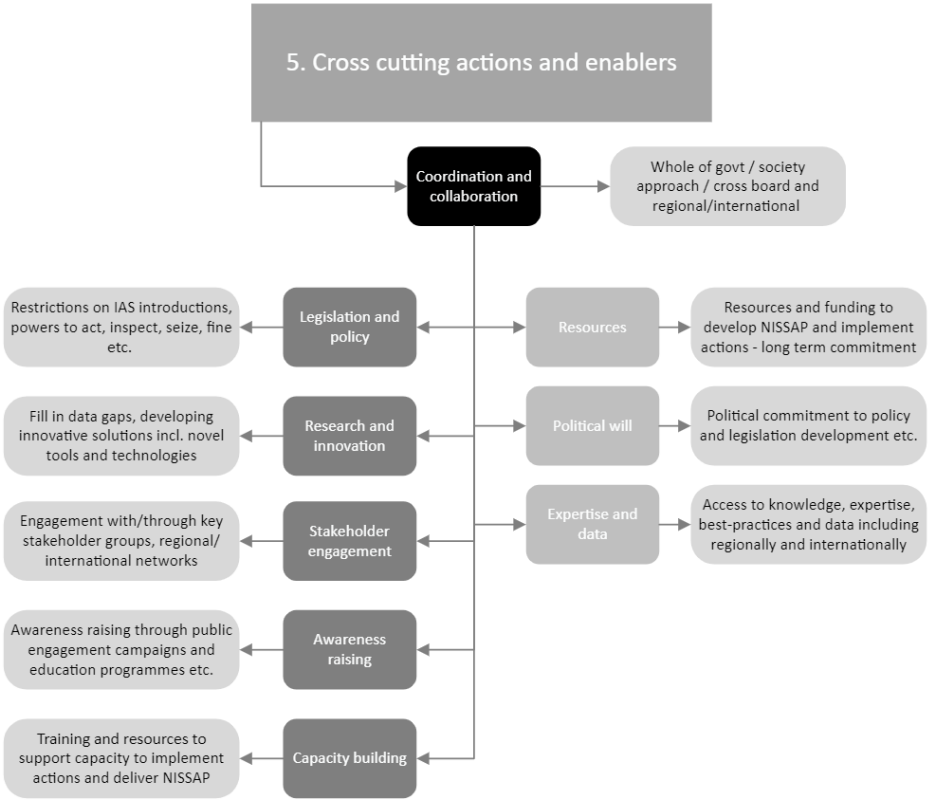
### iii. Adapt

A NISSAP should be a dynamic document where evidence, decision-making and actions are updated regularly to reflect the latest situation and information. Adaptive management allows interventions and actions to be implemented based on the best available evidence, which can be reviewed and refined or updated as new information becomes available, with the aim to reduce uncertainties and improve efficiency. Sharing of management information including both successes and failures is important to continually improve best practise. Regular reviewing of the NISSAP, following acquisition of new information and assessment of data gaps through monitoring and evaluation, can re-align priorities and management actions to ensure continued appropriate resource allocation.

## Step 5. Cross-cutting actions and enablers

To achieve an effective NISSAP a whole-of-government and whole-of-society approach is required to implement actions across sectors and stakeholder groups. Coordination and collaboration are core pillars to enable this, supported by a number of interconnected cross-cutting elements that link to each NISSAP development step. The cross-cutting actions to consider include legislation and policy; research and innovation; stakeholder engagement; awareness raising; and capacity building (figure VIII) which are underpinned by enabling factors including resources, political will and access to expertise and data.

Figure VIII
**Step 5 describes the cross-cutting actions and enablers that support the implementation of actions across all of the other steps**




### i. Legislation and policy

Having robust and effective legislation and policies will underpin actions to prevent the introduction and establishment of alien species and will provide the required mandates for institutions, including for collaboration across sectors.

Enacting legislation takes time and is a complex process, but it can strongly support long-term commitment and resourcing from governments and institutions, which in turn will help guarantee the implementation of the various actions envisaged in the NISSAPs.

Due to the transboundary nature of IAS, pathways and impacts, it can be more efficient to jointly develop regional policy instruments, which require shared objectives and cross-national actions. Collaborative approaches are often more strategic and cost-effective but can challenging and complex to develop.

**ii. Research and innovation**

Enhanced technical and scientific cooperation and technology transfer for state-of-the-art research, innovative management techniques, and environmentally sound technologies will support effective implementation of management actions. A holistic approach through promoting transdisciplinary research and innovation by exploring links with fields such as social sciences, human health, animal welfare and informatics would greatly benefit the advancement of management of IAS.

**iii. Stakeholder engagement**

Response to IAS requires a whole of government and whole of society approach. Governments will need to coordinate actions across multiple departments to develop and implement coherent policies and legislation. Governments can engage in regional and international mechanisms to facilitate joint action and information exchange.

**iv. Awareness raising**

Public understanding of the risks associated with IAS, complemented by their informed cooperation, is critical to preventing new introductions. Awareness raising and education can target a range of audiences and can be undertaken in various places, including schools, community groups or through targeted events.

**v. Capacity building**

It is recognised that the capacity to respond to IAS varies widely across regions, with nearly half of all countries not investing in management of IAS.[132] Identification of where training and support are needed to enable the development and implementation of NISSAPs will increase the capacity to respond. Areas that may require capacity building include species taxonomy and identification, improving data management systems, implementing biosecurity approaches and sharing of best practise methodologies for prioritisation and practical management.

**vi. Resources**

The number of IAS and the magnitude of their impacts will outstrip the resources available for their management. Allocation of sufficient resources to support the development and implementation of a NISSAP should prioritise actions that contribute to prevention and preparedness as these are the most cost-effective options.

Accessing global funding mechanisms can support the resourcing of developing and implementing a NISSAP, such as through the Global Environment Facility[133] which enables developing countries to address complex challenges and work towards international environmental goals, including on IAS. In addition, tax incentives, international standards and cost-sharing mechanisms can be used to encourage stakeholders across different sectors to engage in IAS prevention and management. Under certain conditions, methods such as economic penalties or tariff related regulations, tax relief or subsidies, voluntary codes of conduct, or direct regulatory intervention may also be useful.

[132] IPBES. 2023. Summary for Policymakers of the Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H.E. *et al.* (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430692

[133] Global Environment Facility https://www.thegef.org/

### vii. Political will

At the global level, the inclusion of target 6 in the Kunming Montreal Global Biodiversity Framework demonstrates the global understanding of the negative impacts of IAS and the political will to prevent the damage caused by these species.

Political will, alongside sufficient resources and long-term commitment, is critical to making IAS prevention and control an achievable goal.[134]

### viii. Expertise and data

National, regional and international networks and fora of expertise on invasive species and their management can provide support and advise across all levels of IAS management. Information sharing on taxonomy, risks and impacts and management best practise is aided by a range of freely available online resources and databases. Data sharing (using standardised and harmonised datasets) on invasions improves the knowledge base to inform effective action. There are also global and regional networks of experts on IAS that can be engaged with, for example the IUCN Species Survival Commission Invasive Species Specialist group (ISSG).[135] In addition, the recent 2023 *IPBES the Thematic Assessment Report on Invasive Alien Species and their Control*[136] provides up-to-date information to support management of IAS but also to help raise awareness with decision makers.

[134] IPBES. (2023). Summary for Policymakers of the Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H.E., *et al.* (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430692

[135] IUCN SSC ISSG https://www.iucn.org/our-union/commissions/group/iucn-ssc-invasive-species-specialist-group

[136] IPBES. (2023). Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H.E., Pauchard, A., Stoett, P., and Renard Truong, T. (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430682

# Annex III

## Training materials

## Training material 1. How to use international data standards in national and regional databases containing information on invasive alien species

The Kunming-Montreal Global Biodiversity Framework has 23 action-oriented global targets for urgent action over the decade to 2030, and one of these, target 6, aims to address threats posed by invasive alien species (Box 1).

**Box 1. What are invasive alien species?**

An alien species is a species, subspecies or lower taxon, introduced outside its natural past or present distribution; this includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce[137]. An invasive alien species is an alien species whose introduction and/or spread threaten biological diversity.
Invasive alien species are one of the major drivers of biodiversity loss, and cause dramatic, and in some cases irreversible changes to ecosystems[138]. They have contributed solely or alongside other drivers to 60 per cent of recorded global extinctions and are the only driver in 16 per cent of documented global extinctions[139]. Their impacts occur through different interactions, such as out-competing or predating upon native species, hybridisation, transmission of diseases, or biofouling.

The target aims to eliminate, minimize, reduce and/or mitigate the impacts of invasive alien species on biodiversity and ecosystems. To achieve this, the target sets out three overarching actions, two of which aim to prevent introductions and establishments of new invasive alien species, and the third aims to eradicate or control existing invasive alien species, especially in priority sites, such as islands.

Data is fundamental for identifying and prioritising invasive alien species, pathways of introduction and management actions as required for meeting target 6. It also enables the establishment of baselines and progress towards targets and goals or interventions to be monitored. One of the essential requirements for countries to assess, manage and monitor biological invasions is an inventory or checklist of alien and invasive alien species present in the country.

### Developing an inventory or checklist of alien and invasive species

An inventory or checklist is a catalogue and summary of a set of organisms, it includes the organism's scientific name, common name, location, citation and other annotations related to the purpose of development of the checklist, (e.g. status as an invasive alien species). Ideally, such an inventory is dynamic, with new alien species added as they are reported on the territory.

[137] UNEP/CBD/COP/6/20 Alien species that threaten ecosystems, habitats or species.
[138] IPBES. (2019). Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, J. Settele, E.S. Brondízio., H.T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K.A. Brauman, S.H.M. Butchart, K.M.A. Chan, L.A. Garibaldi, K. Ichii, J. Liu, S.M. Subramanian, G.F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. Roy Chowdhury, Y.J. Shin, I.J. Visseren-Hamakers, K J. Willis, and C.N. Zayas eds.. IPBES secretariat, Bonn, Germany. https://zenodo.org/records/3553579
[139] IPBES. (2023). Summary for policymakers of the thematic assessment report on invasive alien species and their control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H.E., Pauchard, A., Stoett, P., Renard Truong, T., Bacher, S., Galil, B.S., Hulme, P.E., Ikeda, T., Sankaran, K.V., McGeoch, M.A., Meyerson, L.A., Nuñez, M.A., Ordonez, A., Rahlao, S.J., Schwindt, E., Seebens, H., Sheppard, A.W., and Vandvik, V. (eds.). IPBES secretariat, Bonn, German. https://doi.org/10.5281/zenodo.7430692

Information and data, to derive baseline information for the region of interest, can be collated from authoritative and reliable resources including results of vegetation and faunal surveys, field guides, biodiversity reports, results of research published in peer-reviewed literature, inspection data, or taxonomic experts. Also, citizen science portals can provide valuable contributions to species checklists in an area. For example, global platforms like iNaturalist[140], eBird[141] and Observation.org[142] have built-in species checklist functionality.

**What are Data Standards?**

Data standards refer to shared rules and conventions to describe, record and structure datasets. Implementing data standards help maintain a proper flow and use of data across institutions and agencies.

In the case of data related to alien and invasive alien species standards for some key data components have been developed over the past two decades through initiatives led by global data providers such as the IUCN Invasive Species Specialist Group (ISSG), Global Biodiversity Information facility (GBIF) and CABI International (table 1). Some of these data standards have been widely adopted for example, terminology related to pathways of introduction of alien and invasive species[143], and terminology to describe mechanism and magnitude of impacts[144]. Data standards to facilitate sharing of biodiversity data have been set by the Darwin Core Standards, maintained by the Darwin Core Maintenance Group and published by the Biodiversity Information Standards (TDWG)[145].

**Minimum information required for a baseline inventory of invasive alien species**

The minimum information required to develop a baseline inventory or checklist to manage and monitor biological invasions, includes the scientific and common name of the species, its provenance or origin, its pathway of entry or introduction, its occurrence status (presence/absence), its degree of establishment (invasion status), and information on impacts on natural areas and native species. See table 1 for a list of data components that may be recorded in the baseline inventory or checklist.

Baseline information should be maintained and updated on a regular basis if possible. Since data and information on invasive alien species is often held by different institutions for various purposes (i.e. customs, animal and plant health), collating this information may require engagement across ministries. Databases and resources can be national or sub-national, regional, or global.

A list of invasive alien species that are currently known or suspected to have impacts on biodiversity and ecosystems within the geographic location of interest is usually the most accessible information with which to start. This can be extended to include alien species known to have been recorded in the country. As a starting point there are freely available global and regional databases including the Global Register of Introduced and Invasive Species (GRIIS)[146] which provides national checklists of alien species and is openly available on the Global Biodiversity Information Facility (GBIF). These

[140] iNaturalist https://www.inaturalist.org/, also see 'places' https://www.inaturalist.org/places
[141] eBird https://ebird.org/home
[142] Observation.org https://observation.org/
[143] A hierarchical framework of pathways of introduction of alien and invasive alien species at two levels of class and subclass, was developed in response to a request from Parties to the CBD (CBD/COP/XI/28) . The pathways classification scheme can be found here https://www.cbd.int/doc/meetings/sbstta/sbstta-18/official/sbstta-18-09-add1-en.pdf
[144] Impact data standards- The Environmental Impact Classification for Alien Taxa (EICAT) is the IUCN global standard for measuring the severity of environmental impacts caused by animals, fungi and plants living outside their natural range https://iucn.org/resources/conservation-tool/environmental-impact-classification-alien-taxa
[145] Darwin Core https://www.tdwg.org/standards/dwc/#darwin-core-list-of-terms
[146] The Global Register of Introduced and Invasive Species (GRIIS) presents inventories or checklists of introduced and invasive species for a suite of geographical entities such as countries, islands, protected areas etc. GRIIS which is maintained by the IUCN ISSG was developed as a product of the Global Invasive Alien Species Information Partnership (GIASIP) of the CBD. GRIIS inventories or checklists, that can be accessed through country profiles on the CBD website were intended to support countries to achieve Aichi Target 9 https://griis.org/

can be supplemented by additional information from a variety of sources, including reports, surveys and consultation with local experts.

Alien species lists do not need to be complete to be useful, partial lists can provide a good starting point for an action plan. Recognising knowledge gaps in the baseline data is important.

Table 1
**Data components to consider including when developing an inventory or checklist of alien and invasive alien species. Data components and Descriptors in italics are optional**

| Data component | Descriptor | Data Standards |
|---|---|---|
| Taxon ID. [147] | Index number or Record ID | |
| Geographic location such as country, island, protected area, lake etc. | Geographic location which is the subject of the inventory or checklist | Use of the ISO Code[148]; Darwin Core standards |
| Species name (including sub species, varieties, forms where relevant) | Scientific name | Darwin Core standards |
| Taxonomic status (if the scientific name is an accepted name or synonym)[149] | Use a selected taxonomic backbone for example GBIF Species matching tool. | Darwin Core standards |
| Higher taxonomy | Kingdom, Phylum, Class, Order, Family | Darwin Core standards |
| Habitat or Environment | Terrestrial, freshwater, brackish, marine or host | Darwin Core Standards; IUCN Red List Habitat Classification scheme[150] |
| Occurrence status | If the species is present, absent, eradicated or if its presence is uncertain | Darwin Core Standards; GRIIS |
| Provenance or Origin | If the species is alien, cryptogenic (of uncertain origin), or a native \| alien (native to the country and introduced by humans outside its native range in that same country) | Darwin Core Standards; GRIIS |
| Native range | The native range of the species (natural distribution area). | World Geographical Scheme for Recording Plant Species Distribution (WGSRPD), UN geoscheme for other spp. |
| Invasiveness | Status – invasive (If the species has displayed any negative impacts in that country) | GRIIS; Darwin Core Standards |
| Degree of establishment | The stage in the invasion process a species has reached. | Darwin Core Standards |

[147] In a database, it is important that each name has a unique identifier to support querying and analysis of the data.
[148] ISO Codes https://www.iso.org/iso-3166-country-codes.html
[149] When looking for information on a species, it is important to consider taxonomic changes, as valuable information could be published under an "old" name that is now considered a synonym
[150] IUCN Red List Habitat Classification Scheme https://www.iucnredlist.org/resources/habitat-classification-scheme

| Data component | Descriptor | Data Standards |
|---|---|---|
| *Date of introduction or first report* | *This data is useful to map trends of species introductions and is often used for policy indicators* | GRIIS; Darwin Core Standards |
| *Pathways of introduction* | *If the species was introduced intentionally or unintentionally and the type of introduction pathway* | CBD Hierarchical pathway schema;[151] Darwin Core Standards |
| *Impact data including mechanisms of impact and outcome of the impact* | *Mechanisms can include predation, hybridization resulting in outcomes such as population decline* | The Environmental Impact Classification for Alien Taxa (EICAT) and Socio-economic impact classification of alien taxa (SEICAT)[152] |
| Citation or Reference | Source of data | Darwin Core standards (preferably DOI) |
| Date of recording | To record the history of any modifications made | Darwin Core standards |
| Other data | Other data can include for e.g. if the species is managed | |

**Additional reading**

GBIF (2017) Best Practices in Publishing Species Checklists, version 2.1. Copenhagen: GBIF Secretariat. https://ipt.gbif.org/manual/en/ipt/3.0/best-practices-checklists

An Essential Biodiversity Variable Approach to Monitoring Biological Invasions: Guide for Countries an Essential Biodiversity Variable Approach to Monitoring Biological Invasions: Guide for Countries. GEO BON Technical Series (2) <https://www.geobon.org/downloads/biodiversity-monitoring/technical-reports/GEOBON/2015/Monitoring-Biological-Invasions.pdf>

IUCN Red List categories and criteria, version 3.1 <https://portals.iucn.org/library/node/7977>

European Commission, Directorate-General for Environment, Harrower, C., Scalera, R., Pagad, S. *et al.*, *Guidance for interpretation of the CBD categories of pathways for the introduction of invasive alien species*, Publications Office, 2020, https://data.europa.eu/doi/10.2779/6172

Pagad S, Genovesi P, Carnevali L, Schigel D, McGeoch MA (2018) Introducing the Global Register of Introduced and Invasive Species. Scientific Data, 5, 170202. <https://www.nature.com/articles/sdata2017202>

[151] https://www.cbd.int/doc/meetings/sbstta/sbstta-18/official/sbstta-18-09-add1-en.pdf
[152] Socio-economic impact classification of alien taxa (SEICAT) <https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/2041-210x.12844>

# Training material 2. Understanding pathways of introduction and identification

The Kunming-Montreal Global Biodiversity Framework has 23 action-oriented global targets for urgent action over the decade to 2030, and one of these, target 6, aims to address threats posed by invasive alien species (Box 1).

**Box 1. What are invasive alien species?**

An alien species is a species, subspecies or lower taxon, introduced outside its natural past or present distribution; this includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce[153]. An invasive alien species is an alien species whose introduction and/or spread threaten biological diversity.

Invasive alien species are one of the major drivers of biodiversity loss, and cause dramatic, and in some cases irreversible changes to ecosystems[154]. They have contributed solely or alongside other drivers to 60 per cent of recorded global extinctions and are the only driver in 16 per cent of documented global extinctions[155]. Their impacts occur through different interactions, such as out-competing or predating upon native species, hybridisation, transmission of diseases, or biofouling.

The target aims to eliminate, minimize, reduce and/or mitigate the impacts of invasive alien species on biodiversity and ecosystems. To achieve this, the target sets out three overarching actions, one of which aims to identify and manage pathways of introduction of invasive alien species, the second to prevent the introductions and establishments of new invasive alien species, and the third to eradicate or control existing invasive alien species.

The identification of pathways, both past and present, and their prioritisation for management actions is therefore fundamental for meeting Target 6.

## 1. What are pathways of invasive alien species of introduction?

The first stage of the invasion process is human-assisted movement of living organisms (or propagules) beyond their native range, which is associated to several pathways and vectors.

In invasion ecology, pathways are defined as the routes and mechanisms of the introduction and spread of invasive alien species[156]. However, the term ‘pathway’, as currently used in the invasion literature, is more complex, as it represents a “combination of processes and opportunities resulting in the movement of propagules from one area to another, including aspects of the vectors involved, features of the original and recipient environments, and the nature and timing of what exactly is moved”[157] (Box 2).

[153] Decision VI/23 Alien species that threaten ecosystems, habitats or species.

[154] IPBES. (2019). Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, J. Settele, E.S. Brondízio., H.T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K.A. Brauman, S.H.M. Butchart, K.M.A. Chan, L.A. Garibaldi, K. Ichii, J. Liu, S.M. Subramanian, G.F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. Roy Chowdhury, Y.J. Shin, I.J. Visseren-Hamakers, K J. Willis, and C.N. Zayas eds.. IPBES secretariat, Bonn, Germany. https://zenodo.org/records/3553579

[155] IPBES. (2023). Summary for policymakers of the thematic assessment report on invasive alien species and their control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H.E., Pauchard, A., Stoett, P., Renard Truong, T., Bacher, S., Galil, B.S., Hulme, P.E., Ikeda, T., Sankaran, K.V., McGeoch, M.A., Meyerson, L.A., Nuñez, M.A., Ordonez, A., Rahlao, S.J., Schwindt, E., Seebens, H., Sheppard, A.W., and Vandvik, V. (eds.). IPBES secretariat, Bonn, German. https://doi.org/10.5281/zenodo.7430692

[156] Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien specieshttps://eur-lex.europa.eu/eli/reg/2014/1143/oj

[157] Richardson, D.M., Pyšek, P. and Carlton, J.T. (2011). A compendium of essential concepts and terminology in invasion ecology. In: Fifty years of invasion ecology. The legacy of Charles Elton. Richardson, D.M. ed.. Wiley-Blackwell, Oxford. pp. 409 – 420.

**Box 2. Definitions of pathways and vectors**[158]

*Pathways:*

- geographic route by which a species is moved outside its natural range (past or present);
- corridor of introduction (e.g. road, canal, tunnel); and/or
- human activity that gives rise to an intentional or unintentional introduction.

*Vectors:*

- physical means or agent (i.e. aeroplane, ship) in or on which a species moves outside its native range (past or present).

Pathways and vectors can lead to both intentional and/or unintentional introductions. Examples of the latter are activities, such as fisheries, agriculture, forestry, horticulture, shipping (including the discharge of ballast waters), ground and air transportation, construction projects, landscaping, aquaculture including ornamental aquaculture, tourism, research, the pet industry and game-farming[159]

The increase in globalisation is considered the main driver of species movement around the world. Globalisation is associated with an increase in transport, trade, travel and tourism which provide pathways for species to cross those biogeographical barriers that limited their native range. Once transported to a new region, alien, and potentially invasive, species can subsequently move, or be transported, from that region to other new regions.

Understanding the importance of specific alien species' pathways is seen as critical for preventing the movement and spread of alien species, hence for managing the threat they pose to native species and habitats.

Identifying and prioritising the pathways of species introduction into a territory is the first step towards developing pathway action plans. A standardised pathway terminology and classification framework has been established by CBD.[160]

**Identifying pathways of introduction**

Identifying and prioritising the pathways of introduction of past and future alien species introductions into the territory is the first step towards developing pathway action plans. Ideally this information will be collated during the generation of the species lists and will use the standardised pathway terminology and classification produced under the CBD (enclosure).

Identification of the actual (and potential) pathways involved in the introduction and spread of an alien species can be challenging. To support this process, some guidance[161] has been developed, including decision tree flow charts, and species examples for each pathway.

The pathway of introduction for many species may not be known for certain because of lack of documented evidence, and may need to be inferred retrospectively, e.g. by considering pathways assigned to the same species in other countries, or through expert consultation. Moreover, more than one pathway can be assigned to a species.

Consideration of pathways of introduction could be extended to include the pathways of spread, as many alien species may be introduced into a territory by one pathway (e.g. aquarium trade) but then spread via another (e.g. biofouling on boats).

[158] Genovesi, P. and Shine, C. (2004). European strategy on invasive alien species: Convention on the Conservation of European Wildlife and Habitats (Bern Convention). Council of Europe https://www.cbd.int/doc/external/cop-09/bern-01-en.pdf

[159] CBD COP Decision VI/23 Alien species that threaten ecosystems, habitats or species.

[160] Pathways of introduction of invasive species, their prioritisation and management UNEP/CBD/SBSTTA/18/9/Add.1 www.cbd.int/doc/meetings/sbstta/sbstta-18/official/sbstta-18-09-add1-en.pdf

[161] IUCN. (2018). Guidance for the interpretation of the CBD categories of pathways for the introduction of invasive alien species. Technical report prepared by IUCN for the European Commission. https://op.europa.eu/en/publication-detail/-/publication/f8627bbc-1f15-11eb-b57e-01aa75ed71a1

Once the pathways have been allocated to all listed species of a given area and within a defined timeframe, it will be possible to assess patterns and trends in pathways of introduction. This will allow for the identification of those pathways that have led to the introduction of alien species in the past, and those that are relevant for future introductions, as they may be different. It is also possible to prioritise pathways as it will allow the assessment of which ones deserve greater attention in a given area or timeframe.

**Pathway analysis and prioritization**

Addressing the important pathways of introduction and/or spread is key to tackle the introductions and spread of invasive alien species.

The systematic examination of the various routes through which alien species are introduced or spread, helps to clarify which human activities have caused the introduction. The analysis can focus on pre-border (pre-invasion) or post-border pathways of introduction or spread.

Pathways of introduction can change over time, with new pathways created, for instance, because of new trade patterns, new transport routes, altered human activities, climate change, seasonality or in response to pathway management efforts. Pathway analysis should consider a timeframe relevant for the current situation and near future and focus on active and anticipated pathways. Ideally the analysis is regularly updated to account for changes in introduction patterns.

Pathway analysis builds on the information mobilised through pathway identification for invasive alien species, including quantification of the frequency of introductions through that pathway and the volume of organisms or species it represents. The analysis can evaluate factors such as the volume of traffic along the pathway, the likelihood of known invasive species being transported along the pathway, the vulnerability of the receiving ecosystems and the potential impact of the alien species if introduced.

The analysis of pathways allows to prioritize the main routes of entry (Box 3), either by assessing the highest volume of invasive species or pathways associated with species with the greatest severity of impacts, where management interventions (such as border controls) will have the greatest chance of reducing impact or propagule pressure.

The result can provide a basis for decision making and relevant management, possibly considering the CBD hierarchy (UNEP/CBD/COP/6/23) where prevention is most cost-effective, followed by early detection and rapid response, followed by eradication, containment and long-term control measures. It can help identify the feasibility of targeting the riskiest pathways and select pathways that are worth being addressed by dedicated pathways action plans.

**Box 3. Methods for prioritising pathways of introduction**

Prioritising pathways of introduction involves the following steps:

- Pathway identification with quantification of the frequency of introductions through that pathway, the volume of organisms or species it represents.
- Pathway analysis to evaluate factors such as the volume of traffic along the pathway, the likelihood of known invasive species being transported along the pathway, the vulnerability of the receiving ecosystems and the potential impact of the alien species if introduced.
- Pathway prioritization based on their potential contribution to the introduction and spread of problematic alien species and the feasibility of their management.

**Case study**

In accordance with Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014, on the prevention and management of the introduction and spread of invasive alien species, EU Member States are required to carry out detailed analyses of the pathways of unintentional introduction to their territories. The purpose of these analyses is to identify those

pathways which require priority action, due to either the volume of species or the potential damage caused by the IAS entering the Union through them. Based on the result of these analyses, Member States are also required to establish and implement one single action plan or a set of action plans to address the priority pathways identified. Action plans are expected to describe the measures to be adopted and, as appropriate, voluntary actions and codes of good practice. The action plans for pathways developed by EU Member States are available in the Eionet Central Data Repository https://cdr.eionet.europa.eu.

## Enclosure

### The pathways categorization under the Convention on Biological Diversity for the introduction of alien species[162]

| | Category | Subcategory |
|---|---|---|
| Movement of commodity | Release in nature | Biological control<br>Erosion control/ dune stabilization (windbreaks, hedges, …)<br>Fishery in the wild (including game fishing)<br>Hunting<br>Landscape/flora/fauna "improvement" in the wild<br>Introduction for conservation purposes or wildlife management<br>Release in nature for use (other than above, e.g., fur, transport, medical use)<br>Other intentional release |
| | Escape from confinement | Agriculture (including Biofuel feedstocks)<br>Aquaculture / mariculture<br>Botanical garden/zoo/aquaria (excluding domestic aquaria)<br>Pet/aquarium/terrarium species (including live food for such species)<br>Farmed animals (including animals left under limited control)<br>Forestry (including reforestation)<br>Fur farms<br>Horticulture<br>Ornamental purpose other than horticulture<br>Research and ex-situ breeding (in facilities)<br>Live food and live bait<br>Other escape from confinement |
| | Transport – contaminant | Contaminant nursery material<br>Contaminated bait<br>Food contaminant (including of live food)<br>Contaminant on animals (except parasites, species transported by host/vector)<br>Parasites on animals (including species transported by host and vector)<br>Contaminant on plants (except parasites, species transported by host/vector)<br>Parasites on plants (including species transported by host and vector)<br>Seed contaminant<br>Timber trade<br>Transportation of habitat material (soil, vegetation, …) |
| Vector | Transport - stowaway | Angling/fishing equipment<br>Container/bulk<br>Hitchhikers in or on airplane<br>Hitchhikers on ship/boat (excluding ballast water and hull fouling)<br>Machinery/equipment<br>People and their luggage/equipment (tourism)<br>Organic packing material, in particular wood packaging |

[162] From UNEP/CBD/SBSTTA/18/9/Add.1.

| | | |
|---|---|---|
| | | Ship/boat ballast water<br>Ship/boat hull fouling<br>Vehicles (car, train, …)<br>Other means of transport |
| Spread | Corridor | Interconnected waterways/basins/seas<br>Tunnels and land bridges |
| | Unaided | Natural dispersal across borders of invasive alien species that have been introduced through pathways 1 to 5 |

## Training material 3: Priority sites and areas

The Kunming-Montreal Global Biodiversity Framework has 23 action-oriented global targets for urgent action over the decade to 2030, and one of these, target 6, aims to address threats posed by invasive alien species (Box 1).

**Box 1. What are invasive alien species?**

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Invasive alien species are one of the major drivers of biodiversity loss, and cause dramatic, and in some cases irreversible changes to ecosystems[164]. They have contributed solely or alongside other drivers to 60 per cent of recorded global extinctions and are the only driver in 16 per cent of documented global extinctions[165]. Their impacts occur through different interactions, such as out-competing or predating upon native species, hybridisation, transmission of diseases, or biofouling.

The target aims to eliminate, minimize, reduce and/or mitigate the impacts of invasive alien species on biodiversity and ecosystems. To achieve this, the target sets out three overarching actions, two of which aim to prevent introductions and establishments of new invasive alien species, and the third aims to eradicate or control existing invasive alien species, **especially in priority sites**, such as islands (Box 2).

The identification of these sites, and their prioritisation for management actions is to be undertaken by national governments, but what are these sites, how can they be prioritised, and what actions need to be taken in them?

**Box 2. Target 6 on invasive alien species**

The target text is presented below, broken down by colour into its overall aim and elements (actions), one of which has a quantitative aspect.

Eliminate, minimize, reduce and or mitigate the impacts of invasive alien species on biodiversity and ecosystem services by:

**i.** identifying and managing pathways of the introduction of alien species,

[163] Decision VI/23 Alien species that threaten ecosystems, habitats or species.

[164] IPBES. (2019). Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, J. Settele, E.S. Brondízio., H.T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K.A. Brauman, S.H.M. Butchart, K.M.A. Chan, L.A. Garibaldi, K. Ichii, J. Liu, S.M. Subramanian, G.F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. Roy Chowdhury, Y.J. Shin, I.J. Visseren-Hamakers, K J. Willis, and C.N. Zayas eds.. IPBES secretariat, Bonn, Germany. https://zenodo.org/records/3553579

[165] IPBES. (2023). Summary for policymakers of the thematic assessment report on invasive alien species and their control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Roy, H.E., Pauchard, A., Stoett, P., Renard Truong, T., Bacher, S., Galil, B.S., Hulme, P.E., Ikeda, T., Sankaran, K.V., McGeoch, M.A., Meyerson, L.A., Nuñez, M.A., Ordonez, A., Rahlao, S.J., Schwindt, E., Seebens, H., Sheppard, A.W., and Vandvik, V. (eds.). IPBES secretariat, Bonn, German. https://doi.org/10.5281/zenodo.7430692

**ii.** preventing the introduction and establishment of priority invasive alien species, reducing the rates of introduction and establishment of other known or potential invasive alien species by at least 50 per cent, by 2030,

**iii.** eradicating or controlling invasive alien species **especially in priority sites, such as islands.**

The identification and prioritization of sites is important for different aspects of invasive alien species management. There are two broad categories of 'sites'[166], sites that are **sensitive or vulnerable to impacts** from invasive alien species, and sites that are **susceptible to introductions**.

## 2. Sensitive or vulnerable sites

These are sites where if impacts from invasive alien species were to occur, there would be severe consequences to biodiversity or ecosystem services.

Island ecosystems, especially those that are remote[167] and other isolated ecosystems such as mountains, and lake and river systems often support high numbers of species that are found nowhere else on the planet and are known to be highly vulnerable to impacts from invasive alien species. Many of these sites are already under serious threat from biological invasions, as the overwhelming majority of global species extinctions caused by invasive alien species are known to have occurred on islands or other isolated ecosystems[168]. There are other sites that may also be considered as vulnerable, including those that support species or ecosystems of national or global conservation concern or those that are important for the provision of ecosystem services. The identification of these vulnerable sites needs to be done at a national level, but there are several existing international site designation mechanisms and datasets that can be used to support this process (Box 3).

**Box 3. Examples of site designation mechanisms and datasets that can be used to support the identification of vulnerable sites:**

- **Natural World Heritage Sites**[169] - designated for outstanding biodiversity, ecosystem and geological values.
- **Ramsar Sites**[170] – designated wetlands of international importance.
- **Protected and Conserved Areas**[171] - protected areas and other effective area-based conservation measures (OECMs).
- **Key Biodiversity Areas**[172] - sites that support critical populations of the world's threatened species.
- **IUCN Red List of Threatened Species™**[173] - comprehensive information source on the global extinction risk status of animal, fungus and plant species.

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[173] IUCN Red List of Threatened Species https://www.iucnredlist.org/.

### 3. Susceptible sites

These are sites where there is a high risk of introductions of alien species and that provide opportunity for their establishment. They are often habitats that are already degraded and close to areas of high levels of human activity, for example, ports and harbours, large urban areas, tourist sites, or major traffic routes.

### 4. Prioritize sites

To prioritize sites, information on the conservation value of the site can be used, for example the number of endemic or threatened species present and the magnitude of impacts from invasive alien species, with the aim of identifying those where the consequences of impacts from invasive alien species are, or would be, the greatest. In addition, information on the proximity to high-risk areas of introduction and data on presence of alien species can be used to identify those sites that have the highest risk of introductions that can also support their establishment.

Sites where the consequences of impacts are or would be the greatest, and that have a high risk of introduction and establishment, should be considered as a priority. However, before any action is taken, management objectives and feasibility of actions need to be considered.

### 5. Management actions at priority sites

Site based management actions targeting invasive alien species can be highly effective and are known to result in major conservation gains[174]. However, there are different management objectives that should be considered depending upon the circumstances of each site (Box 4).

For sites that are currently undergoing major impacts from invasive alien species, their eradication should be undertaken where feasible[175]. In addition, it is important to also consider eradication of existing alien species that may not be resulting in harmful impacts at present, but could do so in the near future, for example due to climate change. Where eradication is not feasible, containment and control measures should be considered to prevent further spread and reduce impacts.

All vulnerable sites, including those where there are only minor, or even no current impacts from invasive alien species, would benefit from biosecurity practices to prevent new introductions. Surveillance within susceptible and vulnerable sites is also important to detect new alien species at an early stage of invasion, followed by rapid eradication measures. These surveillance actions can target priority invasive alien species and be undertaken both inside and outside of the priority site, for example in areas adjacent to protected areas.

**Box 4. Possible management objectives for priority sites:**

- Eradication of existing IAS leading to greatest impacts
- Eradication of existing IAS that may lead to harmful impacts in the near future
- Where eradication is not feasible, consider containment and control measures to prevent spread and reduce impacts
- Biosecurity to prevent new introductions
- Surveillance to detect new alien species at an early stage of invasion, along with rapid eradication

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