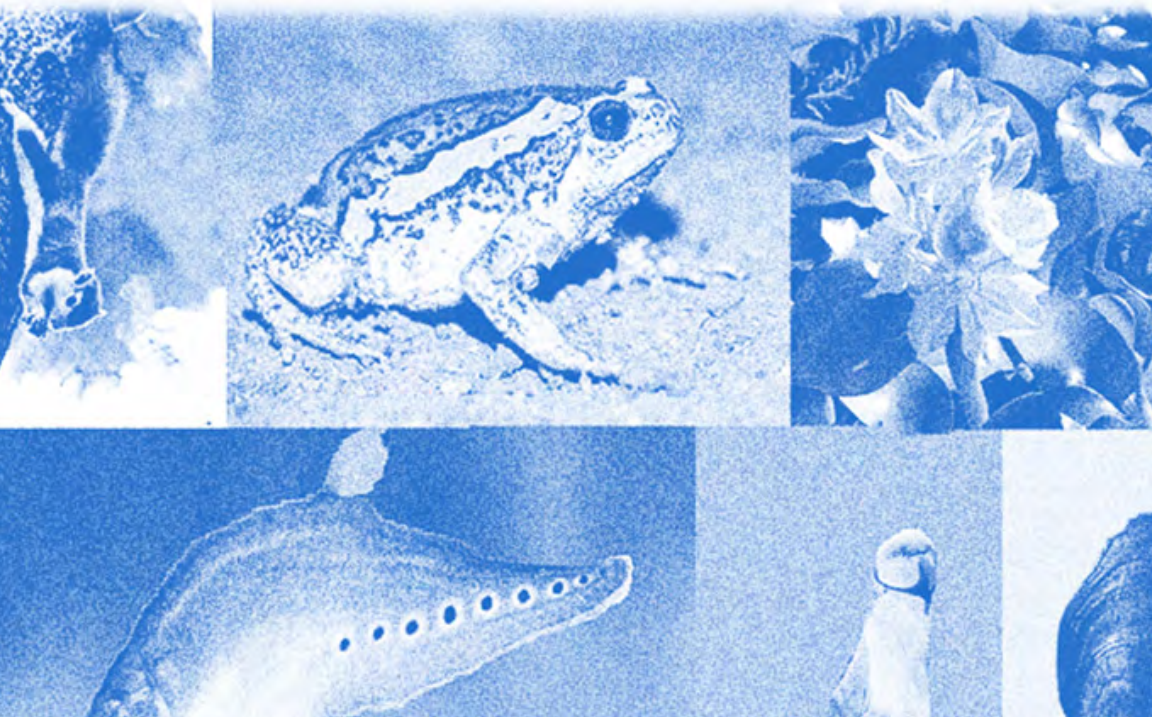


Never Shall Invaders

Policy Options for Managing Invasive
Species Risk with Scientific Information
in the Philippines

Benjamin M. Vallejo, Jr. PhD 

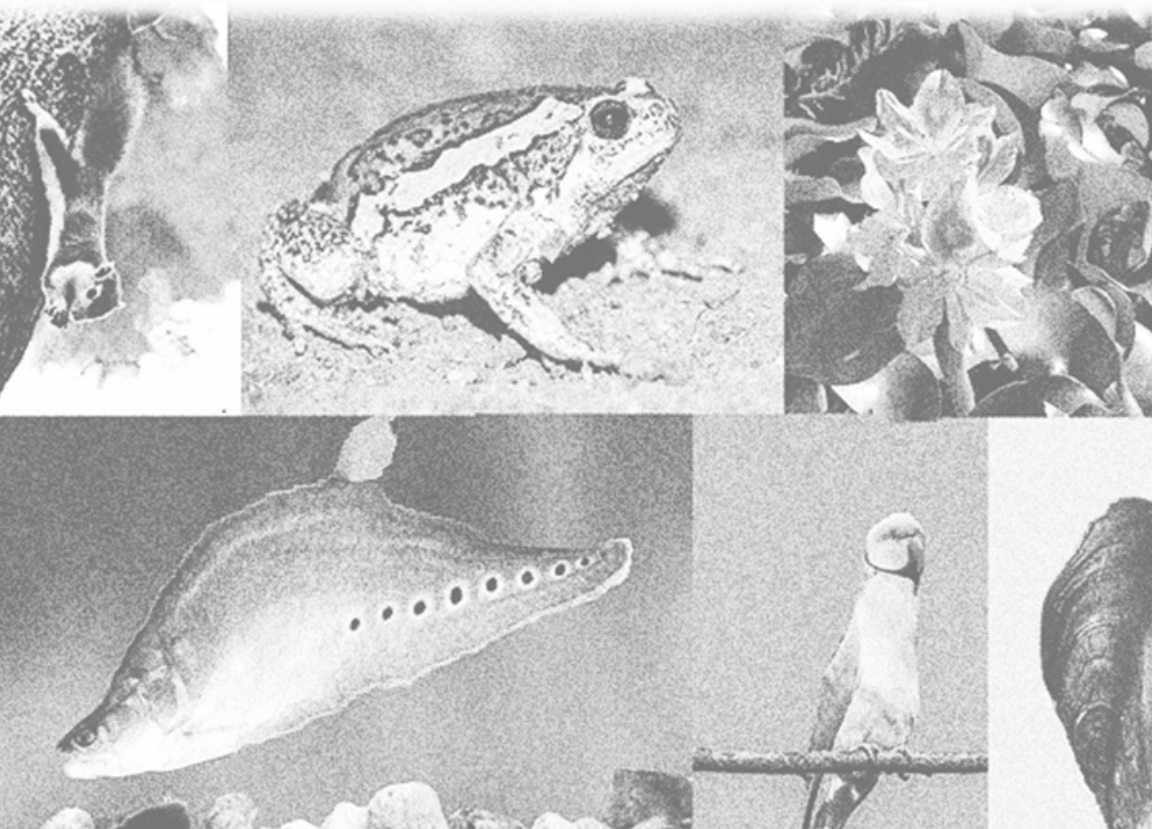


Data Science For Public Policy Program

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"Bioinvasive species"

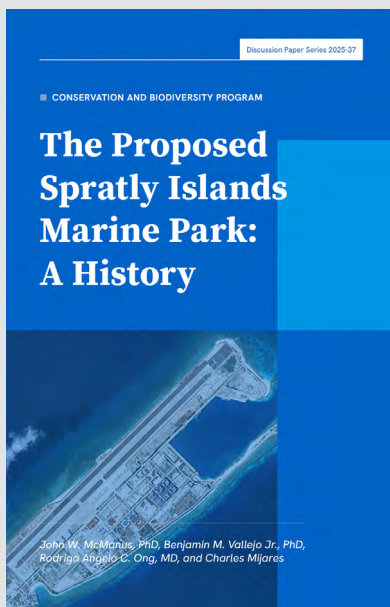
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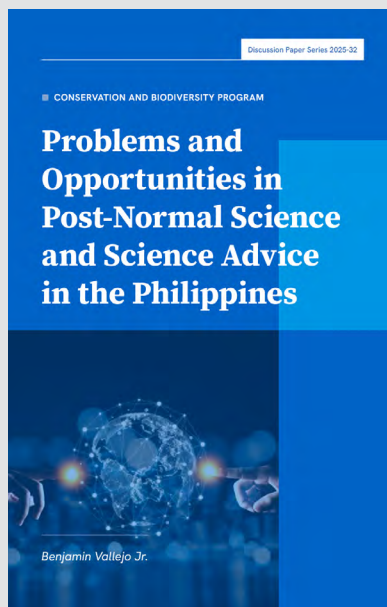
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Philippines



Never Shall Invaders

Policy Options for Managing Invasive
Species Risk With Scientific Information
in the Philippines

Benjamin M. Vallejo, Jr. PhD¹

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Key Highlights

- The Philippines is a megadiverse country facing environmental threats.
- Non-indigenous and invasive alien species are a threat to biodiversity, economy, environment, food security and public health.
- Invasive alien species once established are almost impossible to eradicate. Eradication is costly. Biosecurity risk assessment is the only cost effective option.
- Biological invasion costs the Philippine economy at least 2 B USD a year. But there is no comprehensive national estimate on the costs of biological invasion to the economy.
- Environmental, fisheries and agriculture and customs government agencies implement biosecurity, border control and quarantine regulations. But there is no integrated digital biodiversity databases to inform identification and risk assessment before species are allowed into the country.
- Digital biodiversity databases are available but no digital risk assessment tools are widely used by Philippine biosecurity agencies.
- It is recommended that a comprehensive environmental and economic assessment of biological invasion be conducted.
- It is recommended that an information system using existing biodiversity databases with integrated risk assessment and taxonomic identification tools be created. Artificial intelligence applications will be very appropriate in aiding biosecurity decisions. This need to be supported by relevant policy and legal instruments. Capacitation of biosecurity and customs personnel on using these applications is advised.

Introduction

The Philippines is one of the 17 most megadiverse countries in the world because of its complex archipelagic geography and geological history (Myers et al. 2000; Heaney 1998; Hall 1998). This history has resulted in high levels of endemism in flora and fauna (Steppan, et al. 2003). The country is also part of the Coral Triangle of marine biological diversity and is at the center of the center of global marine biodiversity (ADB 2014; Carpenter and Springer 2005). According to the Philippines Clearing House Mechanism in 2025, there are an estimated 52,177 described species. Table 1 lists the estimated species count of selected megataxa.

Table 1. Biodiversity estimates for the Philippines

Taxon	Total species count	Endemic species count	Percentage endemics
All megataxa	52,177	25,000+	50%
Fish	3,214	121	3.7%
Birds	718	251	34.9%
Vascular plants	9,959	4,278	42.9%
Reptiles	246	354	69%
Amphibians	96	118	81%
Mammals	135	207	65%
Molluscs	8,091	880 (estimate)	4%
Corals	600 (estimate)	12	2%
Insects	20,000 (estimate)	14,000 (estimate)	70%

Not much is known about the microtaxa such as polychaete worms, micromolluscs, and other microscopic species, but it is very likely that these are also diverse taxa with high endemism.

The high biodiversity ecological system is threatened by human population growth, land use changes due to urbanization and agricultural expansion, and extractive resource use including mining, industrialization, and pollution. A more recent threat is the introduction of non-indigenous species (NIS), some of which may be invasive. Invasive species may become damaging to the environment by displacing native species, a threat to public health by spreading zoonotic vectors, and a threat to the agricultural and fisheries blue economy.

The Philippines has a national invasive species plan, The National Invasive Species Strategy and Action Plan (NISSAP) (DENR-BMB 2020) which has a time frame from 2020-2030. NISSAP aims to comply with the Philippines obligations to the Convention on Biological Diversity to minimize the risks of invasive alien species (IAS) and their negative effects on biodiversity. The plan has a multi-stakeholder approach, allowing for relevant government agencies to identify gaps, procedural lapses, and inconsistencies in the national policy and institutional frameworks in managing IAS risks.

NISSAP aims to further capacitate the country's scientific effort, financial allocation, and technical and technological approaches and applications in IAS management. This would require fostering a cooperation among relevant government and non-government organizations (NGOs), industries, local communities, civil society, and other stakeholders. The main goal of the NISSAP is for a collective and coordinated action to reduce the rate of biodiversity loss through the prevention of the introduction and spread of IAS. This is consistent with the Philippine Biodiversity Strategy and Action Plan 2024–2040 (PBSAP) which seeks to reduce biodiversity loss.

Policy Question

The policy question is “How can the Philippines meet its domestic and international legal commitments in managing and reducing the risk of biological invasion using biodiversity information and science tools and approaches?”

Definitions

Environmental DNA (eDNA)	DNA collected from a variety of environmental samples rather from an organism.
Invasive Alien Species (IAS)	is a non-native organism (plant, animal, microbe) introduced to a new area, often by humans, that spreads rapidly and causes significant harm to the local environment, economy, or human health. (syn. Invasive species).
Invasive Aquatic Species (IAqS)	are IAS in marine, freshwater and brackishwater environments.
Indigenous species (IS)	species that have naturally originated, evolved or occur in a particular region or environment.
Intentional introduction	the deliberate introduction and or release of alien or non-indigenous species outside its native range.

Introduced species	Species that are intentionally or unintentionally introduced by humans to a new environment or region.
Native range	Natural limits of a distribution of a species
Non-indigenous species (NIS)	species that have not naturally originated or evolved in a particular region or environment. (Syn. Non-native species or NNS)

Modes and Pathways for Introduction

NIS are introduced to new environments intentionally or unintentionally. If they are introduced intentionally, this often for its perceived and expected economic benefits as a government policy. This is the case for fish NIS and reforestation NIS of trees such as big leaf mahogany *Swietenia macrophylla* which were introduced to accelerate reforestation of denuded landscapes. Tilapias such as Nile tilapia *Oreochromis niloticus*, Mozambique tilapia *Oreochromis mossambicus*, and Black chin tilapia *S. melanotheron* have been introduced beginning in the 1950s to boost fisheries production. The African giant snail *Achatina fulica* was introduced by Japanese occupation forces in 1942 to provide food for the Japanese army. It has since become a pest. The golden apple snail *Pomacea canaliculata* was introduced in around 1982 as a source of inexpensive protein for marginalized communities. Another kind of intentional introduction is biological control for public health objectives. The American live bearing tooth carps, such as the guppy *Poecilia reticulata*, mollies *P. sphenops*, *P. latipinna*, and mosquitofish *Gambusia affinis* were introduced by the US colonial authorities in the first decade of the 20th century to control the spread of malaria, as these fish eat mosquito larvae.

The pet, ornamental plant, and aquarium fish trade are pathways for NIS introduction. The latest estimates indicate that there are at least 35 non-native amphibians, 68 non-native birds, and 200 non-native reptiles for sale in pet shops and from online traders across the Philippines. The estimated number of NIS of aquarium fish in the Philippines is more than 150. While many of these species are likely not able to survive without human care outside enclosures, some have managed to establish themselves, especially in urban environments, often as escapees. Confirmed IAS from pet and aquarium trade include the South American vermiculated armored catfish *Pterogoplichthys disjunctivus*, which was first established in the Pasig-Marikina river system in Luzon and now reported in many freshwater ecosystems in the Philippines from Luzon to Mindanao. Moreover, other examples include clown knife fish *Chitala*

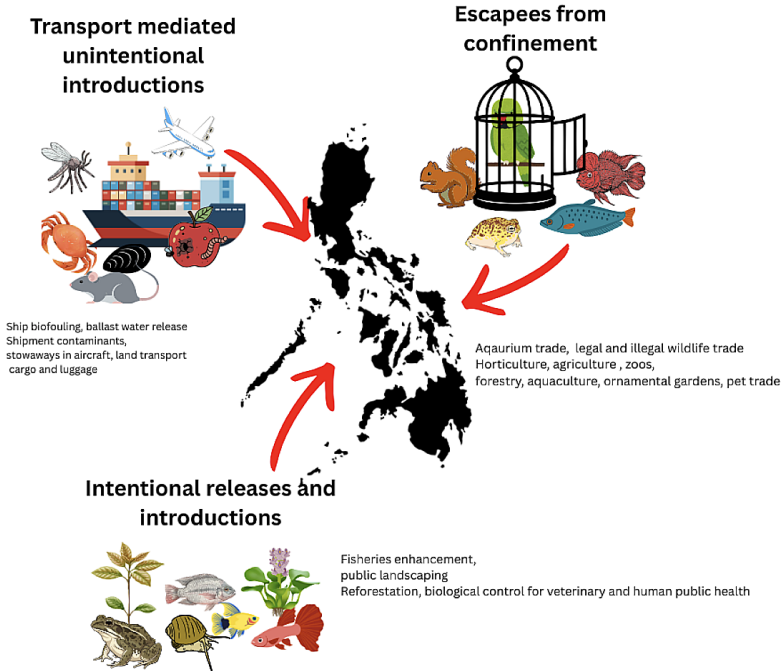


Figure 1. Pathways for NIS and IAS introduction to the Philippines. (Modified from Abreo et al. 2026)

ornata which is now established in Laguna de Bay and the Midas or golden cichlid *Amphilophus citrinellus* which has established in the Seven Lakes of San Pablo, Laguna and the Taal Lake south of Manila. Terrestrial vertebrate pets introduced in the last 50 years include the Indian rose-ringed parakeet *Psittacula krameria*, the Eastern USA red eared slider turtle *Trachemys scripta* subsp. *elegans*, and the Mainland Southeast Asian Finlayson's squirrel *Callioscuiarius finlaysonii*. All these terrestrial invasives were likely to have been introduced in the periurban areas surrounding Manila. They are now established and have breeding populations in Luzon. Without interisland controls in transport, they are expected to colonize the Visayas and Mindanao through their regional cities.

Unintentional introductions result from poor biosecurity protocols and controls. A major vector for this is maritime shipping which can introduce marine biofouling IAS through untreated ballast water release and poor biofouling controls. Other vectors of unintentional IAS introduction are contaminants in shipments, cargo, and luggage and stowaways in cargo holds of ships and aircraft.

Costs of Biological Invasion

There is a global initiative to quantify and estimate the costs of biological invasion using the publicly accessible database InvaCost (Diagne et al 2020). InvaCost uses a global and exhaustive literature reference search for economic cost data for biological invasion worldwide. However, data from the Philippines is very limited. At present, there is no comprehensive assessment of the economic cost of biological invasion in the Philippines. A conservative estimate of USD 2 billion per year for the Philippines has been assessed based on the estimated cost of biological invasion in Asia which is USD 436.2 billion in 2017 (Liu et al. 2021). The Philippines estimate using InvaCost comes from three well documented NIS: the yellow fever mosquito *Aedes aegypti*, the golden apple snail *Pomacea canaliculata*, and the Mango pulp weevil *Sternocetus frigidus*. These three have cost the Philippines economy at least USD 1 billion a year. The yellow fever mosquito is the major vector for dengue and its public health burden to the economy can be as high as USD 600 million a year. The introduction of the golden apple snail may result in up to 90 percent loss of the rice crop in Mindanao as these pulmonate gastropods eat rice plants.

A provincial assessment of the cost of IAS to brackishwater aquaculture in Pampanga was done in 2024. The results suggest that the costs outweigh the benefits with PHP 167,078,535.00 (USD 2,901,920.00) as economic cost to the province compared to the benefits at PHP 52,325,928.00 (USD 908,828.00). One reason is that the incentivized IAS fisheries have lower market value than the traditionally cultured species such as *milkfish Chanos chanos* (Pacunana 2025).

Challenges and Opportunities

Target number six of Kunming-Montreal Global Biodiversity Framework requires parties to accomplish at least a 50 percent reduction of invasive species introduction and establishment in countries by 2030. However, many Southeast Asian countries lack of proper implementation of biosafety protocols (Gaudioso and Zemlo 2007). The Philippines has biosafety and biosecurity policies but need to be revisited and reformed (Destura et al. 2021).

Using evidence-based risk assessment which informs decision tools are important in addressing biological invasion. The Invasiveness Screening Kits (ISK) can be used in minimizing NIS which have invasion potential in establishment in the Philippines (Copp et al. 2016b; Copp et al. 2021; Vilizzi et al. 2022)

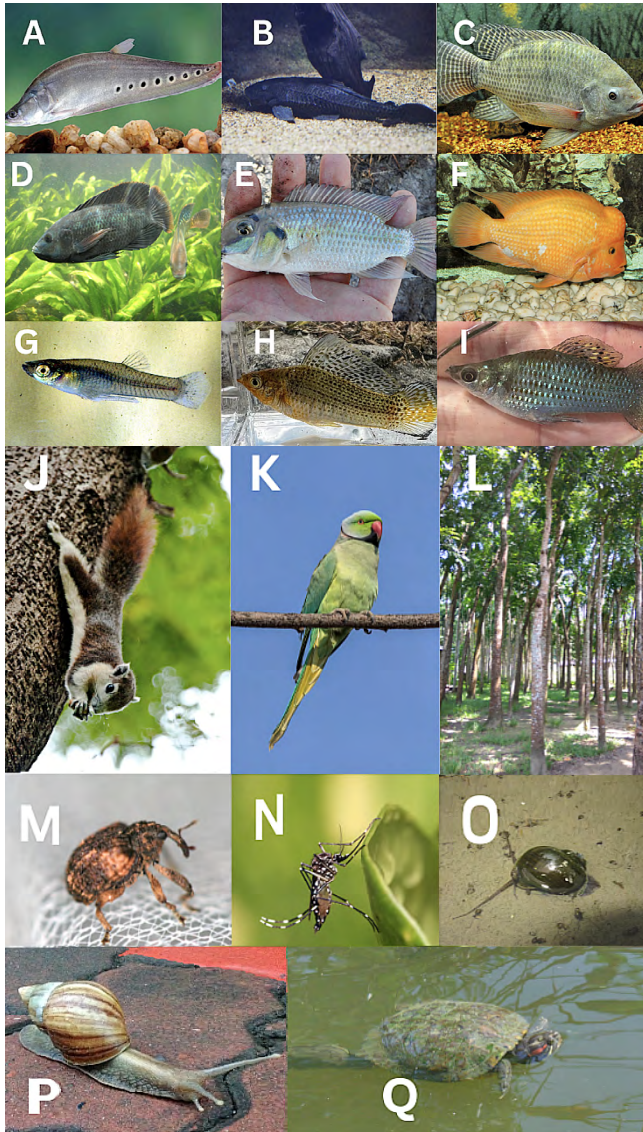


Figure 2. Some confirmed IAS in the Philippines introduced through fisheries enhancement, aquarium and pet trade, agriculture and reforestation.

Fish species: A) Clown knife fish *Chitala ornata*, B) Vermiculated armored catfish *Pterygoplichthys disjunctivus*, C) Nile tilapia *Oreochromis niloticus*, D) Mozambique tilapia *Oreochromis mossambicus*, E) Black chin tilapia *Sarotherodon melanotheron*, F) Midas cichlid *Amphilophus citrinellus*, G) Mosquito fish *Gambusia affinis*, H) Sailfin molly *Poecilia latipinna*, I) Mexican molly *Poecilia spfenops*. Terrestrial and freshwater non-fish IAS: J) Finlayson's squirrel *Callioscuiurus finlaysonii*, K) Rose-ringed parakeet *Psittacula krameria*, L) Big leaf mahogany *Swietenia macrophylla*, M) Mango pulp weevil *Sternochetus frigidus*, N) Yellow fever mosquito *Aedes aegypti*, O) Golden apple snail *Pomacea caniculata*, P) Giant African snail *Achatina fulica*, Q) Red eared slider turtle *Trachemys scripta* subsp. *elegans*. Photo credits for Fig. 2 (M) to the Department of Agriculture, Philippines, all other photos in public domain.

The ISK method and its variants such as the Aquatic Species Invasiveness Screening Kit (AS-ISK), the Terrestrial Animal Species Invasiveness Screening Kit (TAS-ISK), and the Terrestrial Plant Species Invasiveness Screening Kit (TPS-ISK) have been used by the Department of Environment and Natural Resources (DENR) and the Department of Agriculture (DA) and most especially for the AS-ISK, by the Bureau of Fisheries and Aquatic Resources (DA-BFAR). The DA-BFAR has successfully used it to assess the risk of invasion of NIS freshwater fish species of commercial importance.

The ISK then can be used create a watchlist, whitelist, or even a blacklist of NIS that may be introduced to the Philippines. Such risk assessments may allow for the evaluation of commercially important research use and exhibition use NIS for invasion potential and determine approaches to minimize risk such as designing biosecure holding facilities, quarantine protocols, and reducing reproduction risk by single sex cultures or neutering. The ISK can be used for high-risk economic use pathways in fisheries, aquaculture, livestock raising, agriculture and ornamental horticulture.

The key strategy in using ISK is the strict and proper implementation of biosafety protocols. Thus, there is a need to allocate funding for the training of fisheries, animal husbandry, and agriculture border control officials. The main agency for border control in the movement of people to and from the Philippines is the Bureau of Immigration under the Department of Justice. The agency for border control for health is the Bureau of Quarantine under the Department of Health. For terrestrial animal, plant, and fisheries border control and quarantine, this is under Department of Agriculture agencies.

One constraint for ISK strategies is IAS taxonomic and geographic detection bias. Potential commercially important species have a bias at being more studied. These species are likely to be detected adjacent to major international entry ports as evidenced by most IAS detected near Manila (Figure 3).

The implementation of biosafety, quarantine, and risk assessment protocols and the issuance of clearances for the entry of domestic and wild animals is under the DA-Bureau of Animal Industry (DA-BAI). For plants, it is under the DA-Bureau of Plant Industry (DA-BPI). For aquatic animals such as fish, crustaceans, mollusks, and seaweeds it is under the DA-BFAR. Permits are required to transport domestic, wild, and cultured animals and plants into and within the Philippines. These permits are issued by the DA-BAI, DA-BPI, and DA-BFAR as well as by the local governments of the origin and destination of shipments.

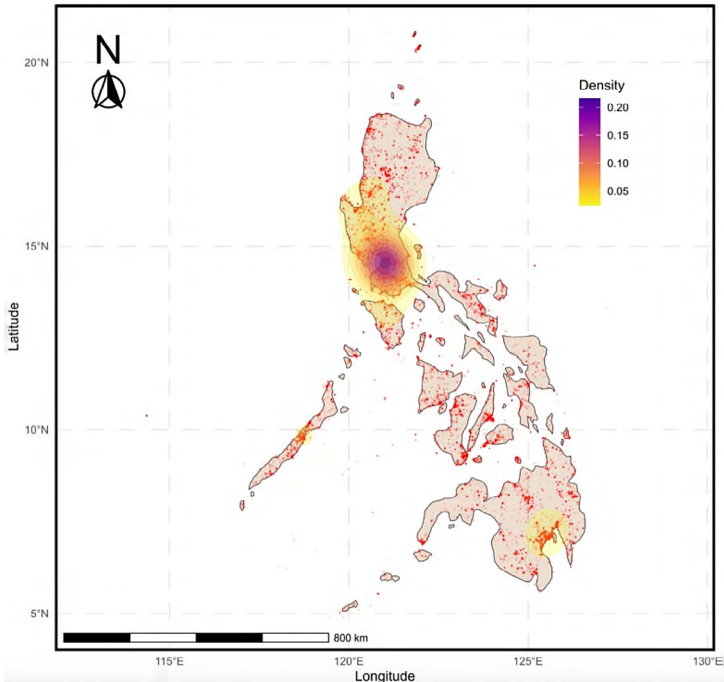


Figure 3. Density of IAS, NIS species occurrences in the Philippines.
(from Abreo et al. 2026)

The ideal outcome of NIS and IAS control is complete eradication of IAS in an area. In most cases complete eradication of IAS may not always be feasible. If it is to be achieved, it will require much costs. The Tropical Atlantic Zebra mussel *Mytilopsis sallei* was discovered in Darwin Harbour, Australia in 1999 (Ferguson 1999). It cost the Northern Territory government AUD 2.2 million to eradicate it from the marina where it was first found. *Mytilopsis* is a marine IAS in Singapore and other ports.

Some IAS have commercial potential, especially those which have been accidentally introduced from ballast water release or hull by hull biofouling (Figure 4). An example is the charru mussel *Mytella strigata* which is a commercial fishery species in its native Brazil but has established in Manila Bay, Lingayen Gulf, Panguil Bay in northern Mindanao, and Aparri, Cagayan. Its ecological niche overlaps with the commercially important indigenous maricultured green mussel *Perna viridis* in the Philippines. The DA-BFAR is considering promoting the species for mariculture as a way of biocontrol. However, the market value of *Mytella* is lower at PHP 30 per kg than that of *Perna* at PHP 120-160 per kg. Furthermore, *Perna* is considered to be

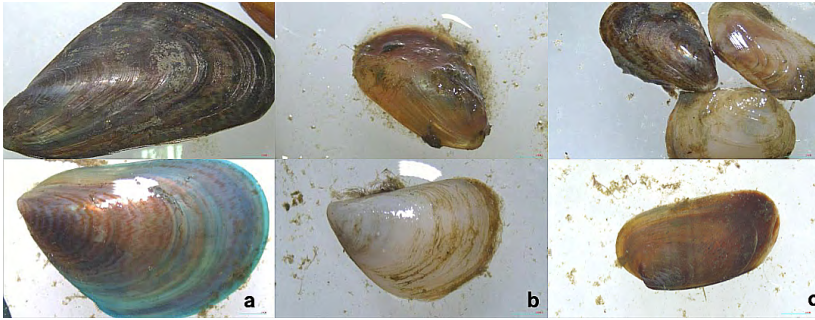


Figure 4. Biofouling bivalves collected from the Port of Manila, Manila Bay.

a) *Mytella* sp., b) *Modiolus* sp., c) *Mytella* sp. and two *Irus* sp.; d) *Perna viridis*, e) and f) are still to be confirmed as *Mytilopsis* sp. and *Brachidontes* sp., respectively. *Mytella* and *Irus* are NIS. *Mytella* is an IAS, *Brachidontes* is a NIS but not a documented invasive, *Irus* is a suspected IAS. *Perna* and *Modiolus* are indigenous. (Ocampo 2026)

tastier. Developing a commercial fishery from IAS is not a new idea. It has been considered for controlling the invasion of the Indo Pacific lionfish *Pterois volitans* in the Caribbean (Yandle et al. 2022) and the Western Atlantic blue crab *Callinectes sapidus* which has established in the Eastern temperate Atlantic and the Mediterranean due to ballast water release. Incentivizing IAS in fisheries as an approach at biocontrol carries its own economic advantages and ecological risks (Klein et al. 2023). One concern is that ecological responses of IAS in novel environments are likely to be different from their native range. This requires intensive biological and life history studies. That *Callinectes sapidus* is commercially valuable is not in dispute. It is also not in dispute that this species is outcompeting the indigenous and commercially valuable European crab *Carcinus meanas*. Incentivizing IAS fisheries require a thorough assessment of fisheries biology parameters, economic gains and losses, impact on local communities, and local cultural practices. Application of the Precautionary Principle is that it is inadvisable to incentivize IAS fisheries as the economic gains are likely to be less than the economic loss due to biodiversity loss and negative environmental impacts.

Science Informed Policy Tools and Frameworks

Linking and interoperation of biodiversity databases

A key science activity here is biodiversity inventories and monitoring. The Philippines has the capacity and scientific expertise to undertake inventories,

and these have resulted in the detection of NIS in the country. However, there needs to have more regular and comprehensive inventories. Funding constraints do not allow these inventories to happen on a yearly basis. Inventories are often done by academic research institutions as part of research project deliverables. While inventories are important, data collected from these efforts need to be curated and stored in a central biodiversity database. While such databases do exist, these are global and taxon-specific databases rather than national in scope. For practical reasons, taxon-specific databases need to be maintained but there needs to be an information linkage between these databases. This would mean that they have an interoperable database architectures and design.

The most notable global biodiversity databases are FishBase² (Froese and Pauly 2010), Sealifebase³ (Palomares et al 2016), World Register of Marine Species (WORMS)⁴ (Costello et al 2013).

Additional databass include Plants of the World Online⁵ (Govaerts 2019), World Flora Online⁶ (Quian et al 2022), and Catalogue of Life (Hernandez-Robles et al 2023).

These databases present taxonomic and distribution information but do not have information packages specifically for IAS and NIS. For this need, especially for marine invasive species, The World Register of Introduced Marine Species (WRiMS)⁷ has links with related global databases to provide a more specific information package for IAS and NIS management. WRiMS is linked with WORMS.

While the global databases can be queried to provide Philippines related information, the Philippines has set up bioweb.ph which is envisioned to be the national repository of Philippine biodiversity data. At the moment, the information comes from the Philippine Clearing House Mechanism (CHM)⁸ with the data of the DENR-Biodiversity Management Bureau. Information

2 <https://www.Fishbase.org>

3 <https://www.sealifebase.org>

4 <https://www.marinespecies.org>

5 <https://www.powo.science.kew.org>

6 <https://www.worldfloraonline.org>

7 <https://www.marinespecies.org/introduced/>

8 <https://www.philchm.ph/>

packages on specific topics can be downloaded from the site. However, the CHM database cannot be queried by users online. They have to submit a data request to CHM.

The importance of accessible taxonomic and species identification databases cannot be overestimated for NIS and IAS risk management. There is a need to have specific information query packages. FishBase and Sealifebase, for example, have the mapping tool and species distribution modelling algorithm called AquaMaps. AquaMaps is a collaborative project that predicts global distribution maps of marine species based in the data of FishBase and Sealifebase overlaid in with climate data in an environmental envelope model. It has been successfully used to model the potential distribution of marine IAS and NIS in the Philippines if they get established (Casiguran 2024) (Figure 5 and 6). It also was able to model biofouler NIS which have been detected using eDNA methods, but have not been ecologically detected. Thus, the approach is powerful to assess potential distributions of NIS and IAS before they are established especially in conjunction with eDNA methods such as in the Atlantic pen shell which has not been ecologically detected in Manila Bay but was detected by eDNA methods (Figure 6).

If such database routines and queries can be customized for the quarantine, customs and border control of plants, fish, and animals, this would make the permit process more efficient and shipment interdiction more effective.

The use of Artificial Intelligence (AI) tools

The use of digital images of species entering a customs area is increasingly useful in customs and wildlife inspections at the border. Since species exhibit phenotypic diversity, human judgement on diagnosing species may fall into error, especially if the diagnostic characters are subtle. Type images can be accessed through the global species databases and digital images of specimens can be assessed by AI image processing to immediately produce a species identification diagnosis. AI is now used in human facial recognition for passport control in immigration processing. The principle for biodiversity diagnosis is similar. If the Philippines has a blacklist of species prohibited from entering the country, a watchlist of species that may be allowed subject to specialized quarantine and husbandry protocols or a whitelist that allows entry, then AI tools will speed up entry processing and customs formalities. AI will also facilitate Decision Support Systems (DSS) for NIS and IAS risk management. AI also can be used for monitoring especially when eDNA methods are used (Shafiq et al 2024).

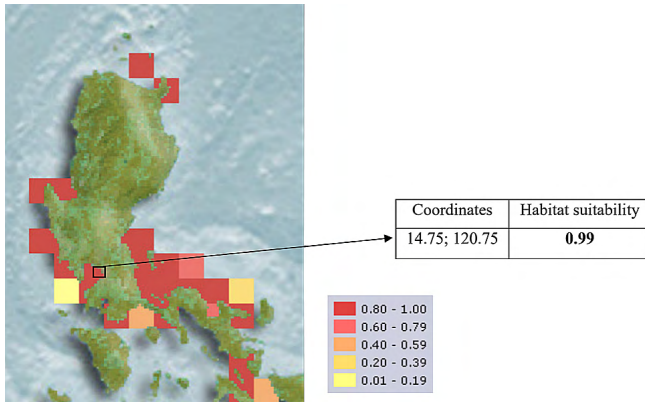


Figure 5. Predicted habitat suitability for biological invasion of the charru mussel *Mytella strigata* in Luzon.

Manila Bay has high suitability. The charru mussel has been ecologically observed as an IAS in Manila Bay since 2014. (Casiguran 2024, Vallejo et al. 2017)

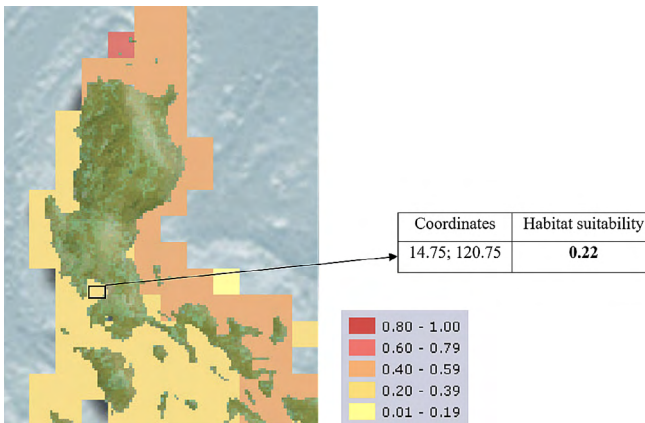


Figure 6. Predicted habitat suitability for biological invasion of the eastern Atlantic and Mediterranean pen shell *Pinna rudis* in Luzon.

This species has been detected using eDNA methods. Manila Bay has low environmental suitability. The probability of this species establishing as an IAS in Manila Bay is low. (After Casiguran, 2024)

AI can allow for faster and more accurate decision making as traditional methods of invasive species detection and diagnosis are labor and resource intensive. Furthermore, AI systems can be deployed in multiple border and quarantine control locations, especially in borders that are mainly involved in cross-border trade of commodities (such as regional ports open to foreign trade). Identifying NIS and IAS with artificial intelligence-enabled image recognition will require good data infrastructure that will allow the

transmitting of data in real-time to data central management hubs. There will be a link between IAS monitoring even at relatively remote locations to data centers in regional capitals and the national capital. Such data can be immediately included to regional and national biodiversity databases such as what is required in CHM.

AI can also be used to predictively model the spread of IAS upon introduction to the Philippines. AI-assisted geospatial modelling has been used to map potential invasion routes and identify high-risk areas for establishment given life history parameters and environmental and climate variables and species tolerance to these factors (Casiguran 2024).

Policy Options and Recommendations

1. Comprehensive capacity to assess ecological impacts and economic losses and gains in NIS and IAS risk assessment

A comprehensive monitoring program to assess costs and losses of NIS and IAS introduction will greatly benefit the Philippines. The program must be able to identify, assess, and manage the risks associated with NIS and IAS. This has three sequential components, risk identification, risk assessment, and risk management. Since there are available international protocols for risk assessments, these can be adapted for the Philippines and must be interoperable and comparable with international systems. The impact and risk assessment will have to include marine, freshwater, and forest ecosystems as well as agricultural, urban, and other anthropized ecosystems. The risk assessment needs integrated socio-economic valuation protocols so a cost-benefit estimate can be provided to policy makers. Further research and development of decision support systems tools are an immediate need. This can be done with collaboration between natural sciences, engineering, and data science departments in Philippine academic and research institutions, the corporate information management sector, the Department of Information and Communication Technology (DICT) and the Department of Science and Technology (DOST).

2. Integrating existing database infrastructures for customs, quarantine and border controls

Since there are existing international global biodiversity databases available, these can be linked with the national biodiversity database of the Philippines CHM. The CHM database must be publicly accessible, with designed

queries for IAS species diagnosis and identification. Specialized query structures can be designed for users in customs, quarantine, and border control so authorities can make quick determinations to allow the entry or non-entry of NIS shipments for agriculture, fisheries, or ornamental uses. The importance of AI tools here cannot be underestimated as human visual species diagnostics can have errors, as species diagnostics can be subtly variable. A digital image bank is useful for these purposes.

3. NIS and IAS distributional and risk modelling policy support

Further research and development is needed in IAS distribution, habitat suitability, and establishment risk. Here it is crucial to integrate climatological, meteorological, ecological, and biogeographical information from other databases. Geospatial mapping tools have been included in global biodiversity databases. These can be included in national biodiversity databases for users in research institutes, fisheries, and agricultural agencies.

4. Capacitation of technical competencies of personnel involved in customs, quarantine, border control, and marine environmental protection

The DA-BAI, DA-BPI, DA-BFAR, DENR-FMB, and the DENR-BMB are responsible for the implementation of biosafety, quarantine, and risk assessment protocols, as well as the issuance of clearances and permits for the entry and export of domestic and wild animals and plants. The DENR-BMB is responsible for certifying terrestrial wildlife holding and care facilities while the DA-BFAR is responsible for certifying fisheries and aquaculture holding facilities. Relevant local governments also certify of the origin and destination of shipments. The personnel of these agencies require training and continuous skills and knowledge upgrading in taxonomic identification, biodiversity risk management and environmental assessment and monitoring when an integrated biodiversity information system is enabled for NIS and IAS risk management.

Most of the IAS recorded in the Philippines is related to the intentional introduction of agricultural, forestry, fisheries, and ornamental commercially important NIS. For unintentional introduction such as what is related to the maritime industry, the Philippine Coast Guard through its Marine Environmental Command (PCG-MEPCOM) is responsible together with the Maritime Industry Authority (MARINA) in the implementation of the Philippines obligations to international maritime environmental protection conventions such as the 2004 Ballast Water

Management Convention. Biofoulers are not intentional IAS introductions and proper hull fouling management, ballast water treatment protocols and periodic port ecological baseline monitoring lessen IAS risks. The PCG-MEPCOM will require the same competencies in IAS and NIS risk management specific to the maritime industry. The University of the Philippines Diliman and Manila campuses have been capacitating the PCG-MEPCOM since 2020. It is recommended that they continue to do so.

Conclusion

Given the importance of biodiversity information in responding to global environmental threats such as biodiversity loss due to biological invasion, Philippines government agencies in agriculture, fisheries, forestry, quarantine, and marine environmental protection need to be able to utilize existing biodiversity information systems in the performance of their mandates in IAS risk and impact assessment. To achieve this, under the existing NISSAP framework and the Philippines CHM, an interoperable global and biodiversity information system is needed with specialized information protocols that will allow for decision support systems such as the ISK for NIS and IAS risk management.

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