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An assessment of the invasive species system in Bangladesh

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Front cover photo: Scouting maize for fall armyworm (*Spodoptera frugiperda*) in Bangladesh. © FAO, Bangladesh, with permission.

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Abstract

The objective of this study was to understand the current status of the invasive species system in Bangladesh, including its responsiveness. A methodology was developed for identifying areas where the system can be strengthened, as well as for establishing a baseline against which changes in the responsiveness of the system can be assessed at a later date, if required.

The current system's strengths and weaknesses were identified through use of a revised methodology including a document review and key informant interviews with participants active within the system in Bangladesh. The process helped to clearly define and start to unpack the invasive species system in Bangladesh as it currently stands.

The study findings demonstrate that the current invasive species system in Bangladesh has some strengths, including a broad range of actors who are aware of the need for invasive species management. One example of a positive response to an invasive alien species (IAS) was the rapid establishment of a National Task Force (NTF) for *Spodoptera frugiperda* (fall armyworm) (FAW) when it was first detected in the country in 2018.

However, challenges to the system remain, including institutional and legislative gaps, the absence of a regulated pest list, monitoring and evaluation limitations, and a severe lack of training and resources. There is a need for support in the implementation of policies and regulations that govern the way IAS are managed, as well as improving the linkages between various actors/organizations. It is also unclear whether responses are the same across all taxonomic groups.

To strengthen the invasive species system in Bangladesh, a central coordinating body should be established that would bring together the various actors in a cross-sectoral and multi-species approach to IAS management, providing an enabling environment for action on IAS in the country. However, it is essential that the coordinating body is also supported by access to resources and capacity building.

Acronyms

AIS	Agricultural Information Service
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BRRI	Bangladesh Rice Research Institute
BTV	Bangladesh Television
BWMRI	Bangladesh Wheat and Maize Research Institute
CABI	Centre for Agriculture and Bioscience International
CBD	Convention on Biological Diversity
CIMMYT	International Maize and Wheat Improvement Centre
DAE	Department of Agricultural Extension
DoF	Department of Fisheries
EDRR	Early detection and rapid response
FAO	Food and Agriculture Organization
FAW	Fall armyworm
IAP	Invasive alien plant
IAS	Invasive alien species
IPM	Integrated pest management
IPPC	International Plant Protection Convention
IUCN	International Union for the Conservation of Nature
NBSAP	National Biodiversity Strategy and Action Plan
NGO	Non-governmental organization
NISSAP	National Invasive Species Strategy and Action Plan
NPPO	National Plant Protection Organization
NTF	National Task Force
PPW	Plant Protection Wing
PRA	Pest risk assessment
PQW	Plant Quarantine Wing
SAAO	Sub-Assistant Agricultural Officers
SAARC	South Asian Association for Regional Cooperation
SDG	Sustainable Development Goal
USAID	United States Agency for International Development
WWF	World Wildlife Fund for Nature

Introduction

An invasive species system is defined as a system that 'consists of all organisations, people and actions whose intent is to combat the threat, spread and effects of invasive species' (Williams *et al*., 2021). The system therefore includes all invasive species whether native species that have become invasive or non-native invasive species, referred to here as invasive alien species (IAS). However, it is likely that IAS cause the most damaging impacts to crops, livestock production and other economic activities, human health and the environment. Therefore, in this assessment we focus on IAS to understand the system, as most current and previous engagement in this area has related to IAS.

Invasive alien species are species that, with human assistance, arrive in new areas and cause damage to crops, livestock production and other economic activities, human health, and the environment. They include microbes, plants, insects, vertebrates and other organisms. A recent example of an IAS is *Spodoptera frugiperda* (fall armyworm, FAW) which was first detected on cabbage and maize crops in Bangladesh in November 2018 (Lamsal *et al*., 2020). This pest is of concern since it has been reported that in Africa it has the potential to cause maize yield loss in the range of 8.3 to 20.6 million tonnes per year if management measures are not implemented (Day *et al*., 2017). Only a small proportion of non-native species become invasive, but those that do cause major direct and indirect losses, including the substantial costs of managing them. Indeed, Dutta *et al*. (2021) report the presence of 148 IAS in Bangladesh.

Increased trade and travel increase the risk of IAS being introduced with climate change enhancing species establishment and spread (Early *et al*., 2016). The impacts from IAS are disproportionately borne by the poor and vulnerable. Many international agreements recognize the threat from IAS, including the International Plant Protection Convention (IPPC), which aims to secure 'common and effective action to prevent the spread and introduction of pests of plants and plant products, and to promote appropriate measures for their control', and the 1992 Convention on Biological Diversity (CBD, 1992; IPPC, 2022).

In South Asia many invasive alien plant (IAP) species have been introduced deliberately as ornamentals and for agro-forestry programmes aimed at reversing severe deforestation. Further species have been introduced to meet the ever-increasing demand from the growing human population, especially for food security, nutrition and fuel needs, leading to the development of aquaculture and cash crops. However, Bangladesh is also one of five countries highlighted as most threatened by IAPs (Paini *et al*., 2016).

Trees such as Australian *Acacia* spp. (*Acacia auriculiformis, A. mangium*) and eucalyptus (*Eucalyptus camaldulensis*) have been introduced to alleviate shortages of timber and fuelwood, while food fish species, such as Nile tilapia (*Oreochromis niloticus*) and common/Mozambique tilapia (*O. mossambicus*), have been introduced to increase the protein component of the human diet but are now considered highly invasive (Mukul *et al*., 2020). Many IAPs were introduced to Bangladesh a long time ago, for example water hyacinth (*Pontederia crassipes*) was introduced during the British colonial period (Pallewatta *et al*., 2003). An historic lack of understanding of the functioning of ecosystems, a lack of information on the life histories of the species introduced, and inadequate dissemination of the lessons learned from introductions of IAS in other parts of the world, has led to the introduction and spread of these species without consideration of the associated risks. The frequency of harmful introductions of IAS appears to be increasing and affecting more of South Asia. The threats posed by

IAS are often 'unseen', as governments of the region have other serious problems that are deemed to require more immediate solutions.

Parties to the Convention on Biological Diversity (CBD) under Article 8 (h) are obligated to: 'prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species'. The guiding principles on IAS adopted by the Sixth Conference of the Parties to the CBD include a three-tiered approach to management: (i) preventing the unintentional or intentional introduction of IAS; (ii) early detection, rapid response and eradication of new invasions (where possible); and (iii) the control and mitigation of species where eradication or containment is not feasible. Signatories to the CBD therefore have a responsibility to manage IAS.

As a signatory to the CBD, Bangladesh has committed to implementing resolutions related to the convention. National Biodiversity Strategies and Action Plans (NBSAPs) are the principal instruments for implementing the CBD at the national level. Bangladesh's NBSAP 2016–2021 refers to 'adopting national measures and standards to deal with invasive alien species (IAS) and genetically modified organisms'. According to the plan, the introduction of IAS is a threat to local species and is included among the main threats to biodiversity. The NBSAP sets the target: 'By 2021, study on the impact of IAS will be furnished, regulations towards the control of IAS will be developed and capacities at the port-of-entries will be enhanced to regulate IAS' (DfE, 2016). Bangladesh also has a commitment to the Sustainable Development Goals (SDGs). Goal 15.8 states: 'By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species', and Aichi target 9 'By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment'. Indeed, the CBD toolkit on IAS aims 'to empower CBD Parties to integrate relevant standards, agreements, and guidance developed by other major international instruments into their National Invasive Species Strategy and Action Plans (NISSAPs) and the IAS components of the National Biodiversity Strategies and Action Plans (NBSAPs) [and] provide opportunities for governments to envision and enact a comprehensive approach to minimising the spread and impact of IAS.' (CBD, 2011).

However, for many countries this can be challenging due to multiple factors related to lack of policy or its effective implementation, inadequate (if any) coordination, little capacity, limited awareness, insufficient resources and competing demands on these limited resources, alongside a lack of lack of clarity, and evidence, about the actual cost of the damage caused by IAS (Paini *et al*., 2016; Pratt *et al*., 2017; Eschen *et al*., 2021a, 2021b), and the lack of a well-functioning system through which to undertake management actions (Williams *et al*., 2021). One step towards enabling countries to improve their IAS management response is therefore to understand the current functioning of the invasive species system within the country, its strengths and weaknesses, and opportunities for building the system, which would contribute towards development of a NISSAP, which is currently lacking for Bangladesh.

Williams *et al*. (2021) set out a theoretical framework and approach for describing and assessing the responsiveness of countries to the threat of invasive species. This can be used to identify opportunities for strengthening countries' invasive species systems, as well as for offering a baseline which can be used at a later date to document changes in responsiveness. This approach was trialled in Kenya in 2019, where those involved in the Kenyan invasive species system engaged in a participatory self-

assessment of the functioning of the system. This work highlighted the strengths of the current system in Kenya, but also some weaknesses.

Based on the work in Kenya, the study reported in this working paper aimed to carry out a similar assessment in Bangladesh, as a first step towards supporting the further development of the invasive species system in the country. The key objectives of this work were to understand the existing invasive species system in Bangladesh, including:

- different actors' roles, responsibilities and mandates in delivering the system functions
- the nature of interactions between actors
- how the system as a whole is operating/delivering its mandate(s)

The aim of the study is to assist in planning the next steps for Bangladesh's invasive species system, based on the understanding and insights gathered. The results can form either a baseline assessment, or can contribute to a comparative assessment if the study is repeated, to understand changes in the system over time.

Method

The methodology, piloted in Kenya, for the assessment of the invasive species system consisted of a literature/document review, a stakeholder workshop and key informant interviews. The same approach was planned for Bangladesh in 2020. However, due to the COVID-19 pandemic and global travel and meeting restrictions, a modified approach was adopted that concentrated on a literature/document review and more comprehensive key informant interviews. The assessment process in Bangladesh consisted of the following elements:

- a document/literature review identifying key actors within the invasive species system in Bangladesh
- key informant interviews with identified actors

Document/literature review

A desk review of the invasive species system within Bangladesh was conducted, using key documents. The aim of the review was to provide a general understanding of the system and its functioning within Bangladesh, and to highlight which areas needed particular follow-up and inquiry. The review also helped to identify key participants for the key informant interviews.

The desk review assisted in identifying the government departments involved in invasive species prevention, early detection and rapid response (EDRR), and control, and the various key actors who contribute to the system functioning. Contextual factors, such as the policy environment, were also noted. The desk review considered policies relevant to agriculture, the environment and invasive species specifically, as well as more general policies (e.g. on governance structures and institutional mandates), that determine how policies are implemented. A lot of this information was readily available from government websites, and donor and research reports. The general sources/types of documents/information that were reviewed included:

- overview documents regarding the government structure
- overview documents regarding the structure of the Ministry of Agriculture and departments responsible for extension, crop protection, livestock management, quarantine and diagnosis, and links with local government structures
- overview documents regarding the structure of the Ministry of Environment and departments responsible for environmental protection, climate change, wildlife management etc.
- agricultural and environment policy documents/development plans
- information on the function of regulatory bodies e.g. the National Plant Protection Organization (NPPO) and the pesticide control body
- information on any involvement of the Ministry of Trade or Ministry of Health in invasive species management
- information on the knowledge of private traders, import/export companies, agro-dealers and transporters on IAS management
- information on national research organizations and universities
- country NPPO information relating to the IPPC
- donor country papers e.g. from the Food and Agriculture Organization (FAO), the International Union for the Conservation of Nature (IUCN) and the World Wildlife Fund (WWF)
- country statistics e.g. from FAOSTAT and the World Bank
- working papers and other publications
- research papers on IAS in Bangladesh

Information was readily available from government websites and donor and research reports. The document review acted as a good entry point for starting to understand the context. However, official policy and institutional arrangements do not always reflect the reality on the ground, so key informant interviews were conducted to help us understand what is really happening in Bangladesh in terms of the invasive species system.

Key informant interviews

Following the document/literature review, key informant interviews were conducted during September and October, 2020. The process involved conducting online interviews with representatives identified as key actors in the invasive species system in Bangladesh. Representatives from the following organizations were included in the interview process:

- Ministry of Agriculture, including the South Asian Association for Regional Cooperation (SAARC)
- Agriculture Information Centre and the Agriculture Information Service (AIS)
- Department of Agricultural Extension (DAE)
- Bangladesh Agricultural Research Institute (BARI)
- Arannayk Foundation

- WorldFish
- Institute of Forestry and Environmental Services
- Chittagong University
- International Maize and Wheat Improvement Centre (CIMMYT)
- Bangladesh Wheat and Maize Research Institute (BWMRI)
- Bangladesh Rice Research Institute (BRRI)
- Ispahani Agro Ltd
- Syngenta Bangladesh Ltd
- Interviews were also conducted with a Syngenta fertilizer dealer and three smallholder farmers in Chuadanga District.

Standard questions were used concerning the actor's role in IAS management, what other actors they work with, the challenges they face in managing IAS, and their opinion of the need for a coordination body to manage IAS. During the interviews, respondents were invited to assess the country's invasive species system's strengths and weaknesses, from their point of view, and the interviews also sought to capture additional information about contextual influences, such as the policy environment, institutional structures, donor influence, politics and organizational cultures.

Results

Policy and legal framework

In terms of imports, the Import Policy Order 2015–2018 restricts plant imports under the terms of the Plant Quarantine Act 2011, and requires all official imports to be accompanied by a phytosanitary certificate. In line with the recommendation in the NBSAP 2016–2021 this policy should address the issue of IAS in a more stringent way.

As part of ensuring a dependable food security system, the Bangladesh National Agriculture Policy 2013 aims to ensure environmental protection, as well as environmentally friendly sustainable agriculture and the strengthening of Integrated Pest Management (IPM) programmes. The policy envisages a number of measures to achieve these aims such as motivating farmers to use pest-resistant varieties of crops and modern cultivation practices to reduce the incidence of pest infestation; the use of mechanical control measures (such as light traps and hand nets) and biological control measures; regular training and discussion programmes on IPM among farmers under the supervision of the Union Agricultural Development Committee; and strengthening of the pest surveillance and monitoring systems.

The DAE and BARI highlighted the need for improved implementation of existing policies and regulations that govern the way IAS management is delivered and the need for a collaborative approach.

IAS present in Bangladesh

The NBSAP 2016–2021 states that the following IAP species are present in the country: *Pontederia crassipes* (Kachun pana/water hyacinth), *Chromolaena odorata* (Siam weed), *Mikania cordata* (Assam lota/mikania), *Croton bonplandianum* (Bonkhira/jungle tulsi), *Lantana camara* (Kasundi/lantana), *Ageratum conyzoides* (ghag, Billy goat weed), *Cajanus scarabaeoides* (wild kulthi), *Commelina obliqua* (Jotakansira), *Convolvulus arvensis* (bindweed), *Evolvulus nummularius* (Bhuiokra/roundleaf bindweed), *Hyptis suaveolens* (Bon topma/pignut), *Ipomoea carnea* (Dholkalmi/pink morning glory), *Ludwigia adscendens* (Keshordham/water primrose) and *Mimosa pudica* (Lajjaboti/common sensitive plant) (DfE, 2016).

A review of IAS in Northern Bangladesh highlights seven IAP, five of which are included in the NBSAP (above) but also listing *Mikania micrantha* and *Parthenium hysterophorus* (Akter and Zuberi, 2009). A recent literature review by Mukul *et al*. (2020) identified 69 IAS reported to occur in Bangladesh, with the majority of these species plants (46 species), followed by fish (16 species), and insects (five species). According to the *Global Invasive Species Database* (ISSG, 2015) invasive insects present in Bangladesh include *Bemisia tabaci, Diaphorina citri* (a vector of the huanglongbing disease), and the ants *Paratrechina longicornis* and *Tapinoma melanocephalum.* A search of CABI's Invasive Species Compendium (ISC) for all datasheets available for Bangladesh highlights 651 records for invasive species (CABI ISC, 2022). According to the GRIIS database (www.griis.org, accessed October 2020) there are 107 naturalized plant species in Bangladesh (Shresha *et al*., 2022).

Hossain and Pasha (2001) report the following IAS detrimentally impacting Bangladesh ecosystems: *Acacia auriculiformis* (northern black wattle), *Eucalyptus camaldulensis* (red gum), *Leucaena leucocephala* (leucaena), *Acanthospermum hispidum* (bristly starbur), *Senna occidentalis* (senna), *Cestrum diurnum* (day jessamine), and *Alternanthera ficoidea* (Joseph's coat).

Twenty-three alien species (of which four are IAS) are reported present in the Sundarbans mangrove forest, a World Heritage listed site (Biswas *et al*., 2007).

Many of the IAS present in Bangladesh were introduced from South America, Asia, Africa and Australia, primarily to provide food, timber and environmental benefits, but were later identified as a threat to native flora, fauna and ecosystems (Mukul *et al*., 2020).

Key invasive species system actors/organizations

There are a number of actors within the invasive species system in Bangladesh, with various roles and responsibilities. Their main involvement is summarized in the paragraphs below.

Department of Agricultural Extension (DAE) and National Plant Protection Organization (NPPO)

The DAE, within the Ministry of Agriculture, is the largest government agency working to ensure crop production and yield. The DAE has a huge network across Bangladesh, including frontline workers in the field under the extension wing and offices across the country. The DAE is the main contact point for respective research institutions, through the National Agricultural Technical Coordination Committee, which is responsible for technology development for different crops, maintaining technical liaison with concerned industries and officers, collecting information, and transferring technology (the Committee has a mandate to transfer modern technology to farmers). The DAE has strong networks and mechanisms for delivering training and materials to farmers and for acting as a

bridge between farmers and researchers (BRRI, BARI, non-governmental organizations (NGOs) etc.). Another aspect of DAE's role under the Bangladesh National Agriculture Policy is to encourage farmers to ensure judicious use of pesticides. As such, the DAE provides training on reducing chemical pesticide use and the promotion of IPM practices. There are 32 registered biopesticides in Bangladesh. Pest risk assessments for many different crops are also conducted by the DAE and if a quarantine pest is identified on imported goods, at any of the quarantine stations located at sea, land and air ports across the country, the DAE ensures the product is refused entry. For example, when cotton infested with American cotton bollworm (*Helicoverpa zea*) was imported from the Americas, the DAE initiated control by fumigation.

The NPPO in Bangladesh is situated under the DAE and consists of two organizations: 1) the Plant Quarantine Wing (PQW); and 2) the Plant Protection Wing (PPW), which function under the Plant Quarantine Act, 2011.

Plant Quarantine Wing (PQW)

The PQW is a signatory to the World Trade Organization, which commits Bangladesh to sustain international trade and abide by and implement international standards for phytosanitary measures in Bangladesh. The PQW has responsibility for enforcing policy and regulating import and export activities for plants and plant products to ensure the prevention of the introduction of quarantine pests with imported plants, plant products, beneficial organisms and packing materials. In addition to policy enforcement, the PQW's main functions are to incorporate new rules and policies on plant quarantine; promote plant quarantine activities at check/entry points; issue import permits and phytosanitary certificates for agricultural products; issue release orders for plant commodities; and record and intercept pests and diseases. To ensure Bangladesh reaches international standards, the PQW has developed an e-phytosanitary certification system to assist in plant quarantine activities, as well as modernizing its quarantine laboratories at plant quarantine stations. The PQW has 13 laboratory facilities in different regions of the country and provides a screening and diagnostic service for imported products. There are 30 quarantine stations in the country, strategically located at land, air and sea ports.

The PQW's job is complicated by the fact that there is reported to be a lack of awareness of the plant quarantine system among different stakeholders at various levels. For example, in the export supply chain, there is an absence of direct linkages, and a lack of supervised production; traditional exporters pack using bamboo baskets and second-hand paper cartons; and there is no traceability in place.

Plant Protection Wing (PPW)

The PPW is the chemical pesticide registration authority in the country and issues and renews registration certificates and licences for different chemical pesticides and public health products. The PPW is also responsible for providing advisory services to farmers and for organizing and delivering training and capacity building (i.e. workshops/demonstrations/field days, and the provision of various extension tools and printed materials). Routine work includes regular monitoring and surveillance via Sub-Assistant Agricultural Officers (SAAOs) in the Field Service Wing, who work directly with farmers at the field level by providing training and distributing factsheets. These on-the-ground officers are well positioned to conduct pest censuses and identify if a new pest is prevalent (including any IAS). The SAAOs ensure quick and effective pest management by providing farmers with technical advice on control measures. They promote a range of methods to control pests and/or IAS, including IPM.

The PPW has extension personnel in each district, and regional level networks with strong linkages with other organizations, which enable it to collect materials and deliver technologies throughout the country, with the help of research organizations. The PPW also conducts awareness raising through promotional campaigns.

If an IAS is identified, the PPW runs a workshop/information campaign to increase the awareness of those in the environment sector, field officers and farmers. Each SAAO is required to visit five areas under their jurisdiction to conduct surveillance and must then report immediately to a higher level (from sub-district through to district, and up to director level).

The PPW relies on cooperation with other departments/organizations. For example, it works closely with BARI, with whom it has a network, to control any new pest invasions in the country. The arrival of FAW in the country provides an example of this cooperation. Strong actions occurred via networks with BARI, BRRI and other organizations, and a National Task Force (NTF) was rapidly formed, coordinated by the DAE and executed by the Ministry of Agriculture. The NTF consists of various actors, including the Secretary of the Ministry of Agriculture, research organizations, extension services, Bangladesh Agricultural Research Council (BARC), BARI, BWMRI and BRRI, among others. Regional workshops were held in 14 districts, to discuss management and control options, and develop a monitoring system to inform both district and national-level officials. Field activities included instigating the use of traps for monitoring and trials of various pest control methods (with BARI). The DAE (via partners) supported monitoring by provision of resources (pheromone traps) and training for extension agents and farmers. The NTF continues to meet on a monthly basis. This integrated approach to the control of FAW resulted in minimal occurrence of the pest the following year.

The PPW also works with NGOs, the private sector and farming groups on the ground, through linkages with international, national, non-governmental and private organizations.

Bangladesh Agricultural Research Institute (BARI)

BARI, under the Ministry of Agriculture, works closely with the DAE and the NPPO, and has a clear mandate in relation to IAS management. BARI has regional level field stations and around 40 trained entomologists who are who are currently working with ~2,000 pests in the country. BARI is therefore well positioned to identify new IAS occurrences and contribute towards tackling any outbreaks. BARI keeps records and maintains a database for IAS management but currently a shortage of manpower is preventing the fulfilment of this role.

As an example of its role, BARI first identified the presence of FAW in Chuadanga District in 2018 and initiated necessary measures to control the pest under a collaborative approach with the DAE. BARI now heads the Technical Committee providing technical support to the NTF on FAW, as well as conducting monitoring and surveillance activities, reviewing advice and recommended inputs.

National Task Force (NTF) for FAW

As discussed above, the NTF for FAW was established when the pest was first detected in Bangladesh in November 2018. It is executed by the Ministry of Agriculture and coordinated by the DAE, with BWMRI as the member secretary. Active members include BARC, BARI, BRRI, CIMMYT, the United States Agency for International Development (USAID) and CABI. In the initial stages of FAW invasion, the NTF brought together key actors and provided a forum for collaboration on developing an action

plan based on technical expertise. All communication materials or products proposed for dissemination for FAW management were approved by the Technical Committee (headed by BARI), before being endorsed for further use. The NTF provides expertise and technical support, and meets on a monthly basis to discuss specific issues on FAW or any other relevant issues. The FAW NTF has helped to facilitate:

- initial training and capacity building at extension and farmer level in control methods, including mechanical, chemical and biological control
- development of the 'Fall Armyworm Monitor' phone app (see CIMMYT paragraphs below)
- helping to expedite the registration of a biopesticide and a maize seed treatment
- advocacy for ministerial/policy support

International Maize and Wheat Improvement Centre (CIMMYT)

The international organization, CIMMYT has a mandate to work with maize and as such it tackles associated problems, including IAS such as FAW. The organization also works with USAID and FAO on projects relating to forecast-driven early warning systems and sex pheromones. As indicated above, CIMMYT also works in partnership with other organizations in Bangladesh including the DAE, BARI and BRRI on data-driven initiatives to control FAW at the field level. For example, in response to a request from the DAE, CIMMYT helped to develop a very effective monitoring system to track FAW population and damage trends. The 'Fall Armyworm Monitor'[1] is a phone-based app that is used to collect data on FAW field incidence, population dynamics and severity of infestation. The app instructs extension agents how to scan for leaf damage, infested whorls and maize cob damage. The Fall Armyworm Monitor is powered by data collected in real time, through associations with the DAE, BWMRI, BARI, BRRI, the Cereal Systems Initiative for South Asia, and CIMMYT, with support from USAID. The data coming from the Fall Armyworm Monitor can be found on the open access website (https://faw-monitor.firebaseapp.com/#/, accessed Oct 2020). These data assist and empower agricultural development planners, extension agents and farmers to make informed and smart IPM decisions to mitigate the threat posed by FAW.

CIMMYT is also engaged in working with the PPW, which has responsibility for pesticide registration. For example, last year CIMMYT worked collaboratively to expedite the registration of a biopesticide and a seed treatment to tackle FAW. Thus, CIMMYT plays a role in advocacy for low-toxicity pesticides/biopesticides. In the case of FAW, CIMMYT also facilitated taking PQW staff to the field to see first-hand the pest's impact and related management efforts.

Another example of CIMMYT's activities in the invasive species system are provided by the arrival of wheat blast in 2016. CIMMYT's response involved developing a resistant germplasm and operational early warning system for extension agents (with BRRI), screening of fungicides and developing agroecological methods of control.

Bangladesh Wheat and Maize Research Institute (BWMRI)

BWMRI is a relatively newly established research institute that previously worked under BARI but now partners with both BARI and the DAE. BWMRI's mandate is to work in research and training for wheat

[1] The tool was generated by CIMMYT but the information and data shown do not necessarily reflect the views of USAID or the United States Government, and are not used for advertising purposes.

and maize, providing and disseminating technical information at the farmer level. As a newly established research institute, there are some overlaps and gaps between BWMRI's work and that of other organizations. BWMRI is the member secretary of the NTF on FAW and has also worked on *Phthorimaea (Tuta) absoluta* (tomato leaf miner). Linkages also include working with Ispahani Ltd, a private company manufacturing biocontrol products, on promotional activities that raise awareness of these products at the farmer level.

Bangladesh Rice Research Institute (BRRI)

Rice is the staple food of Bangladesh and BRRI is a key organization in the National Agricultural Research System, undertaking research and development in all aspects of rice production. BRRI works towards the development of sustainable, safe and profitable rice technology and has 11 regional offices around the country. The organization works in partnership with the DAE in regard to IAS management. Currently, BRRI report working with rice insect pests and parasites encouraging farmers to use insecticides judiciously, and promoting IPM. Since the arrival of FAW, BRRI has been involved in its management and is an active member of the NTF providing technical support when required.

Arannayk Foundation

The Arannayk Foundation (also known as the Bangladesh Tropical Forest Conservation Foundation) is a not-for-profit company which seeks to contribute to the conservation of the biodiversity assets of Bangladesh's tropical forests. The Foundation's mission is to facilitate the conservation, protection, restoration and sustainable use of tropical forests in Bangladesh by providing financial grants or other support to qualifying organizations or entities. Various exotic tree species have been introduced in Bangladesh, many of which have become naturalized, such as *Acacia nilotica* (gum arabic tree) and *Dalbergia sissoo* (shishu), a fast-growing nitrogen-fixing tree. Other IAPs include *Lantana camara* (lantana), *Leucaena leucocephala* (ipil ipil), Australian *Eucalyptus* spp. (eucalyptus), *Mahonia bealei* (leatherleaf mahonia, also known as Beale's barberry), *Pinus pinaster* (maritime pine), and *Swietenia macrophylla* (mahogany). These can cause huge damage to tropical forests and the wider environment. The Arannayk Foundation undertakes promotional campaigns, including an invasive species/IAS awareness programme, to help people to manage these species.

Ispahani Agro Ltd.

Ispahani Agro Ltd. produces and markets environmentally friendly agro-products for pest management, including pheromone traps, biopesticides, bio-fungicides and biocontrol agents, which are very popular at the farmer level. Although Ispahani Agro Ltd. is not directly involved with the national-level taskforce for FAW management it works in partnership with the DAE at the field level, where it promotes environmentally friendly agro-solutions and IPM.

Syngenta Bangladesh Ltd.

Syngenta Bangladesh Ltd. produces high-quality seeds, planting technology and crop protection solutions to help smallholder farmers increase the yield, production and quality of their crops. Syngenta also carries out a number of stewardship activities focusing on safe applications of chemical pesticides. Syngenta has worked with the DAE and CIMMYT on FAW management, initiating steps to control the pest at the field level via its network of around 500 distributors and 10,000 dealers in the country. Syngenta has two separate registered chemical pesticides for the control of FAW which have

had high success rates and are popular with farmers. Syngenta also provides technical support at the field level and organizes retailer training.

Agricultural Information Service (AIS)

The AIS is a government organization under the Ministry of Agriculture whose mandate is to deliver modern agricultural information and technologies to farmers at the grassroots level through mass media. The AIS collects agricultural information from research, academia, extension and other knowledge centres and converts it into farmer-friendly formats which can then be disseminated through different mass media channels, such as print (e.g. Krishikotha, Samprosharon Barta) and electronic media (e.g. Bangladesh Television (BTV), Bangladesh Betar, community radio, video materials etc.). The AIS uses various information communication technologies and engages in other innovation activities to provide necessary advanced agricultural information at the farmer level, including the Agriculture Information and Communication Centres, Krishi Call Centre – 16123, Smart Agriculture, e-books, websites, apps and other initiatives available nationally. As such, the AIS has the potential to play a role in the control of any kind of IAS infestation by disseminating the correct information through its established information systems.

The AIS works jointly with the DAE, along with other organizations, including FAO, CIMMYT, CABI and the national-level taskforce. For example, the AIS is currently working with CABI on the dissemination of information in video, audio and print format to raise awareness of the management of FAW, especially using biological control. During the COVID-19 pandemic, the AIS has been increasingly relied upon to deliver messages to farmers.

Organizations active on invasive fish species

Invasive alien fish species have a negative impact in the fisheries sector in Bangladesh. Approximately 150 different invasive alien fish species have already been released or introduced in Bangladesh, 15 of which are from the fisheries sector and are highly detrimental to the environment. Invasive alien fish species can have huge impacts on the ecosystem, such as negative impacts on indigenous varieties of fish, as well as implications for human health. There have been collaborative efforts by Bangladesh Fisheries and Research Institute and the Department of Fisheries (DoF) to manage these species. The DoF's mandate is to disseminate improved aquaculture technologies through training, demonstration and extending advisory services to the focal stakeholders, and to enhance fisheries resources through enacting conservation and management measures. However, introduction of invasive alien fish species and their management requires further attention.

Chittagong University

The Institute of Forestry and Environmental Sciences at Chittagong University provides some specific courses on invasive species and IAS management.

Department of Environment, Ministry of Environment and Forests

The Department of Environment is a government department responsible for the protection of the environment in Bangladesh. Unfortunately, we were unable to interview a representative from this department at the time of this study. However, engagement with the Department of Environment is crucial to progressing further discussion and implementing effective measures in the invasive species system in Bangladesh.

Discussion

Strengths of the invasive species system in Bangladesh

There are a broad range of actors, with high levels of technical expertise, active in the IAS space in Bangladesh. For example, BARI has a large number of trained entomologists at strategically located field stations, who work closely with the DAE and the NPPO in identifying potential IAS.

Collaboration among various actors is good and there is willingness to work together when faced with a new IAS. For example, when FAW arrived, the NTF was rapidly formed in recognition of the severity of damage this pest can cause. Subsequently, the 'Fall Armyworm Monitor' tool was developed to help farmers make informed IPM decisions. These activities demonstrate collaborative partnership between various actors.

Many of the key actors identified in the invasive species system belong to various networks that have established linkages, routes of communication and mechanisms for interaction that currently work effectively to respond to farmers' needs. For example, the DAE has highly trained personnel in the PPW/Field Service Wing, who provide farmers with training, information and resources contributing to capacity building, and who are considered a bridge between research institutions and farmers. Other examples include Plantwise plant doctors, agro-dealers and private local service providers who provide field-level support to farmers on managing pests. There are also well-established and varied methods of communication with farmers across the country, including the AIS, which is a valuable resource for dissemination of information on a mass scale.

Some policies and regulations for managing IAS exist alongside policy-level support to encourage the use of IPM and reduce reliance on chemical pesticides to deal with pests. The Plant Quarantine Act, 2011 goes some way towards supporting phytosanitary measures for imports and exports into/out of the country. The NBSAP, a policy document, highlights the risk IAS present as a serious threat to biodiversity, the importance of impact studies and the need for the development of regulations and capacity at ports of entry to regulate introductions.

It was evident throughout the interview process that there is high motivation and dedication from all actors to ensure IAS are effectively managed. There is knowledge and technical expertise across the various actors and their ability to unite was demonstrated by the country's swift and effective response to FAW.

Weaknesses of the Bangladesh invasive species system

Although there are existing policies and regulations that govern the way IAS management is delivered, at the implementation level they are not well executed, thereby limiting effective delivery of IAS prevention, detection and control. Further, there is a focus on addressing crop pests with severe lack of attention towards environmental weeds.

Although collaboration between research and extension departments is occurring on IAS to some extent, there is room for improvement. For instance, collaboration rapidly occurred with the formation of the NTF on FAW, and previously the establishment of a taskforce for wheat blast, however in both instances these were emergency responses. It is also apparent that the agriculture and environment sectors work independently of each other with limited, if any, communication.

Further research into IAS is needed to contribute to up-to-date lists of native and non-native invasive species already present in the country, since current priority lists are incomplete. Horizon scanning for new potential threats is also required to assist in activity planning to ensure appropriate and strong preventative measures are implemented at country borders.

Although IPM is given high importance, it is not well executed at the field level and farmer awareness of biological control is low. At the same time there is a need for a review of the registration process for biologicals, since currently this significantly slows product approval (as demonstrated in the case of biopesticides for FAW control). Promotional activities for biologicals are also lacking. Private local service providers currently have good links with farmers but do not promote and/or provide biologicals although they have an important role to play since farmers look to them for advice when purchasing pest control products.

Bangladesh imports a lot of produce to meet the country's growing food security needs, and therefore there is a clear need to be vigilant for new IAS. Although the PQW has phytosanitary measures in place, these require improvement to ensure effective interception of IAS and prevent them entering the country. Further, screening and/or systemic trials need to be carried out before releasing any species into the environment. The PQW has recognized that in the cases of FAW and wheat blast, quarantine activities were not sufficient, with action only taken after these species had arrived, whereas preventative measures should occur in advance. This is also reflected in the reactive establishment of NTFs in response to specific emergencies.

There is a need for a more proactive approach to IAS management with more surveillance activities and effective implementation of existing rules and regulations on the ground. There is also a need for other actors within the system to play a more proactive role, including other government departments, NGOs and private sector bodies, whose help is needed to promote awareness of IAS at the field level. A related challenge to low levels of knowledge on IAS is that farmers may not be open to or willing to take on new technologies, or if they do apply them, they may lack knowledge of how to do so effectively. Access to and availability of alternative products must be enhanced, for example, pheromone traps were recommended for FAW but were not readily available.

Capacity also needs building in terms of personnel and physical resources. For example, due to a shortage of manpower there are gaps in records and no database of IAS present in the country. Staff shortages also present challenges to opportunities for greater collaboration between various organizations. Greater access to diagnostic laboratories, with highly trained technical staff, would allow for rapid analysis and identification of potential IAS, and ensure quality control. Further, high levels of staff turnover at the government level were reported, resulting in inconsistencies.

Recommendations

The existing linkages between various actors/organizations need to be harnessed to ensure purposeful collaborative efforts between the DAE, research institutions, national and international NGOs, and private sector representatives, in order to successfully initiate the necessary steps and effectively manage IAS. A coordinating body is urgently needed which should involve BARC, as the apex body of the National Agricultural Research System. This coordinating body should facilitate engagement between all actors involved in IAS management from trade to human health. The PQW should be empowered to conduct pest risk assessments, using the latest digital tools, in order to strengthen the system. Currently, a specific taskforce is formed only in response to an emergency, and the

establishment of a national standing multi-threat taskforce involving key actors within the country is urgently required. This taskforce must include representatives from all relevant sectors within the country (i.e. agriculture, forestry, fisheries, environment etc.). The formation of such a cross-sectoral statutory body consisting of local experts, alongside comprehensive standards and procedures, is a priority for developing the country's capacity to manage IAS. It is recommended that this body meet regularly (even when there is no emergency) to share knowledge, experience and skills, build capacity, and identify appropriate pathways for advising government at policy level. The coordinating unit must be supported by a conducive institutional environment with relevant legislation as well as adequate resources in order to facilitate their work. This would help the country to move from the current reactive approach towards being proactive in the face of IAS threats and enhancing advocating activities at multiple levels (including policy level).

Since Bangladesh has extensive borders with neighbouring countries, it is highly vulnerable to further IAS introductions. As such, regional cooperation is important for the management of transboundary pests and these neighbouring countries need to cooperate to share information and research. The existing safeguarding mechanisms for imports of exotic species into the country need to be strengthened, including ensuring there are appropriate (clear and effective) quarantine measures and regulations.

Research into IAS is another priority. For instance, although the NBSAP reports the presence of 15 IAPs there is no comprehensive national list (Shrestha *et al*., 2022). Establishing a comprehensive list of all IAS present in the country would help in determining effective management plans and strengthening existing policies and regulations. Further, horizon scanning for potential new threats, in all sectors, is required to ensure effective preventative measures and future preparedness. For instance, border control agents need to be aware of high-threat species present in neighbouring countries that could easily move into Bangladesh. One key challenge is that currently quarantine sits under agriculture, so the focus is on crop pests, rather than considering IAS in all sectors. Improved collaboration and communication between research and extension is needed. A Pest Risk Assessment (PRA) must be conducted for all exotic species being brought into the country which will differentiate harmful IAS from advantageous (often crop) exotic species. A country-wide monitoring and surveillance programme for existing and new IAS, supported by an open access central repository for information storage is urgently needed. It is essential that the inventory is regularly updated to ensure a comprehensive species list to help facilitate the required action. Research and impact assessments are needed to provide key data, including economic impact, which are essential for securing policy-level support and funding for IAS prevention, detection, control and management. This research would also contribute to updating the country's NBSAP and development of an urgently needed NISSAP.

Increased capacity building for extension agents should be undertaken to improve their awareness of IAS and their ability to advise farmers on appropriate use of chemical pesticides and implementation of IPM at the field level. Robust monitoring of the use of chemical pesticides, based on recommendations from extension agents and/or agro-dealers, should be instituted by selling chemical pesticides on the basis of a prescription. A significant obstacle, which has been highlighted in the case of FAW, is the barrier that the current registration process (which was designed for chemical insecticides) presents for the registration of new biological control products. This process needs redefining. One of the main agro-suppliers reported that they do not provide any kind of biological product, which is not conducive to farmers being able to utilize alternatives to chemical pesticides. Biological control programmes are absent in many countries due to lack of capacity in terms of funding

and human resources and low levels of stakeholder awareness (Day and Witt, 2019). Capacity building of agro-dealers in decision-making tools, like the Plantwise factsheet library and in-country developed apps (i.e. Krihsorjalna) would be helpful. In addition, there is a need for capacity building among farmers for the management of IAS using biological control products, as well as for production at the community level. CABI's BioProtection Portal, which has recently been launched in Bangladesh, provides a list of registered biological products available in the country and will be a useful resource going forward.

Importance also needs to be given to raising awareness of IAS at the beneficiary level, through promotional campaigns, in collaboration with the government, NGOs, the private sector and others involved in the implementation process. Invasive species and IAS communication strategies also need to be developed. The media can play a significant role in informing people of the impact of IAS. Indeed, the AIS has numerous established methods for supporting mass awareness-raising campaigns, as well as the promotion of biological control and IPM, and as such, the AIS and other private media channels should be included in any established body.

It is clearly crucial that the Department of Environment is engaged and included in further discussions and implementation of effective measures in the invasive species system going forward.

Conclusion

Bangladesh faces a challenge in maintaining food production levels to feed its large population, while also experiencing other challenges, such as climate change. As a signatory to the CBD, biodiversity conservation is a national priority; however, a comprehensive assessment and framework for identifying and managing IAS is lacking, and the country does not yet meet the minimal targets outlined in its NBSAP.

It is clear from this study that there are a range of committed and highly competent actors in the invasive species system in Bangladesh. The establishment of a coordinating body to act as a central point in the invasive species system is essential to bring together these various actors and ensure collaborative working. The NTF, created to tackle FAW, demonstrates what such a coordinating body could look like and what these combined efforts can achieve. Alongside increased capacity building at the field level, and greater policy support at the implementation level, there is the potential for the invasive species system in Bangladesh to be significantly strengthened and increasingly proactive in response to and management of IAS.

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References

Akter, A. and Zuberi, M.I. (2009) Invasive alien species in Northern Bangladesh: Identification, inventory and impacts. *International Journal of Biodiversity and Conservation* 1(5), 129–134. https://doi.org/10.1016/j.gecco.2020.e01196

Biswas, S.R., Choudhury, J.K., Nishat, A. and Rahman, M.M. (2007) Do invasive plants threaten the Sundarbans mangrove forest of Bangladesh? *Forest Ecology and Management* 245, 1–9. https://doi.org/10.1016/j.foreco.2007.02.011

CABI ISC (2022) Invasive Species Compendium. Available at: https://www.cabi.org/isc/ (accessed 21 January 2022).

CBD (Convention on Biological Diversity) (1992) Convention on Biological Diversity. United Nations, 28 pp. Available from: https://www.cbd.int/doc/legal/cbd-en.pdf (accessed 4 February 2019).

CBD (Convention on Biological Diversity) (2011) Aichi Biodiversity Targets. Available at: https://www.cbd.int/sp/targets/ (accessed 4 February 2019).

Day, M. and Witt, A.B. (2019) Weed bio logical control: challenges and opportunities. *Weeds* 1(2), 34–44. Available at: https://weeds-apwss.scholasticahq.com/article/11532-weed-biological-control-challenges-and-opportunities (accessed 2 February 2022).

Day, R., Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M., Colmenarez, Y., Corniani, N., Early, R., Godwin, J., Gomez, J., Gonzalez Moreno, P., Murphy, S.T., Oppong-Mensah, B., Phiri, N., Pratt, C., Silvestri, S. and Witt, A. (2017) Fall armyworm: Impacts and implications for Africa. *Outlooks on Pest Management* 28(5), 196–201. https://doi.org/10.1564/v28_oct_02

DfE (Department of Environment, Ministry of Environment and Forests, Government of the People's Republic of Bangladesh) (2016) *National Biodiversity Strategy and Action Plan of Bangladesh 2016-2021 (NBSAP 2016-2021)*. Department of Environment, Ministry of Environment and Forests, Government of the People's Republic of Bangladesh, xvi + 119 pp. Available at: https://www.cbd.int/doc/world/bd/bd-nbsap-v2-en.pdf (accessed 4 February 2019).

Dutta, S., Wong, L.J. and Pagad, S. (2021) Global Register of Introduced and Invasive Species - Bangladesh. Version 1.9. Invasive Species Specialist Group ISSG. Checklist dataset. https://doi.org/10.15468/yopfzd (accessed 18 January 2022).

Early, R., Bradley, B.A., Dukes, J.S., Lawler, J.J., Olden, J.D., Blumenthal, D.M., Gonzalez, P., Grosholz, E.D., Ibañez, I., Miller, L.P., Sorte, C.J.B. and Tatem, A.J. (2016) Global threats from invasive alien species in the twenty-first century and national response capacities. *Nature Communications* 7, 12485, 9 pp. https://doi.org/10.1038/ncomms12485

Eschen, R., Beale, T., Bonnin, J.M., Constantine, K.L., Duah, S., Finch, E.A., Makale, F., Nunda, N., Ogunmodede, A., Pratt, C.F., Thompson, E., Williams, F., Witt, A. and Taylor, B. (2021a) Towards estimating the economic cost of invasive alien species to African crop and livestock production. *CABI Agriculture and Bioscience* 2(18), 18 pp. https://doi.org/10.1186/s43170-021-00038-7

Eschen, R., Beale, T., Bonnin, J.M., Constantine, K.L., Duah, S., Finch, E.A., Makale, F., Nunda, N., Ogunmodede, A., Pratt, C.F., Thompson, E., Williams, F., Witt, A. and Taylor, B. (2021b) Correction to: Towards estimating the economic cost of invasive alien species to African crop and livestock production. *CABI Agriculture and Bioscience* 2(30), 4 pp. https://doi.org/10.1186/s43170-021-00052-9

Hossain, M.K. and Pasha, M.K. (2001) Alien invasive plants in Bangladesh and their impacts on the ecosystem. In: *Assessment and Management of Alien Species that Threaten Ecosystems, Habitats and Species*. CDB Technical Paper No. 1. Secretariat of the Convention on Biological Diversity, Montreal, Canada, pp. 73–75. Available at: https://www.cbd.int/doc/publications/cbd-ts-01.pdf (accessed 14 February 2022).

IPPC (International Plant Protection Convention) (2022) International Plant Protection Convention. Available at: https://www.ippc.int/en/ (accessed 14 February 2022).

ISSG (Invasive Species Specialist Group) (2015) Global Invasive Species Database. http://www.iucngisd.org/gisd/search.php (accessed 4 February 2019).

Lamsal, S., Sibi, S. and Yadav, S. (2020) Fall armyworm in South Asia: Threats and management. *Asian Journal of Advances in Agricultural Research* 13(3), 21–34. https://doi.org/10.9734/AJAAR/2020/v13i330106

Mukul, S.A., Khan, M.A.S.A. and Uddin, B.U. (2020) Identifying threats from invasive alien species in Bangladesh. *Global Ecology and Conservation* 23, e01196, 12 pp. https://doi.org/10.1016/j.gecco.2020.e01196

Paini, D.R., Sheppard, A.W., Cook, D.C., Barro, P.J. De, Worner, S.P. and Thomas, M.B. (2016) Global threat to agriculture from invasive species. *Proceedings of the National Academy of Sciences, USA* 113(27), 7575–7579. https://doi.org/10.1073/pnas.1602205113

Pallewatta, N., Reaser, J.K. and Gutierrez, A.T. (eds) (2003) *Invasive Alien Species in South-Southeast Asia: National Reports & Directory of Resources*. Global Invasive Species Programme, Cape Town, South Africa, 111 pp. Available at: https://www.doi.gov/sites/doi.gov/files/uploads/invasive_alien_species_in_south_southeast_asia.pdf (accessed 2 February 2022).

Pratt, C.F., Constantine, K.L. and Murphy, S.T. (2017) Economic impacts of invasive alien species on African smallholder livelihoods. *Global Food Security* 14, 31–37. https://doi.org/10.1016/j.gfs.2017.01.011

Shrestha, B.B., Witt, A.B.R., Shen, S., Khuroo, A.A., Shrestha, U.B. and Naqinezhad, A. (2022 in press) Plant Invasions in Asia. In: Clements D.R., Upadhyaya, M.K., Joshi, S. and Shrestha, A. (eds) *Global Plant Invasions.* Springer Nature Switzerland AG.

Williams, F., Constantine, K.L., Ali, A.A., Karanja, T.W., Kibet, S., Lingeera, E.K., Muthike, G., Rwomushana, I., Godwin, J. and Day, R. (2021) An assessment of the capacity and responsiveness of a national system to address the threat of invasive species : a systems approach. *CABI Agriculture and Bioscience* 2(42), 17 pp. https://doi.org/10.1186/s43170-021-00062-7

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