

Strengthening the system for invasive species preparedness and management: Bangladesh

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Front page photo: Stakeholders attending the final validation workshop to assess the functioning of the Bangladesh invasive species preparedness and management system, December 2023, Dhaka (photo: CABI, with the permission of the subjects).

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Abstract

The objective of this study is to assess the status and responsiveness of the invasive species preparedness and management system in Bangladesh. More specifically, it aims to evaluate the capacity of the national system for invasive species preparedness and management, provide insights on how the system responded to the most recent fall armyworm (FAW) infestation and identify opportunities for strengthening the system. Building upon a framework and methodology piloted by CABI experts in Kenya in 2021, this assessment utilised stakeholder engagement workshops, which involved stakeholders across 17 institutions and demonstrated that, despite strong performance by national government institutions, the overall system does not sufficiently prevent, detect and control invasive species and executes inadequately the functions of risk analysis, quarantine, surveillance and diagnostic services. Based on stakeholder consensus and pre-existing plans, a National Action Plan was produced by stakeholders to create a road map for strengthening the system for invasive species preparedness and management in the country. Altogether, this study offers a holistic assessment of the invasive species preparedness and management system in Bangladesh and allows stakeholders to outline steps towards increasing the capacity and responsiveness of the system.

List of acronyms and abbreviations

BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BNH	Bangladesh National Herbarium
BSMRAU	Bangabandhu Sheikh Mujibur Rahman Agricultural University
CBOs	Community Based Organizations
CIMMYT	International Maize and Wheat Improvement Center
DAE	Department of Agriculture Extension
DoE	Department of Environment
DoF	Department of Fisheries
DoFL	Department of Forestry and Livestock
FAW	Fall Armyworm
IPM	Integrated Pest Management
MoFL	Ministry of Fisheries and Livestock
NARS	National Agriculture Research Systems
NGOs	Non-Governmental Organizations
NPPO	National Plant Protection Organization
NTF	National Task Force
PPW	Plant Protection Wing
PQW	Plant Quarantine Wing

Introduction

Invasive species are species (such as microbes, weeds, insects, vertebrates and other organisms) that, with human assistance, deliberately or inadvertently, arrive in new areas and cause damage to crops, livestock production and other economic activities, human health, and the environment (Mooney and Hobbs, 2000; Simberloff, 2013). 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. Climate change and increased trade and travel increase the risks of invasives (Hellmann *et al.*, 2008; Hulme, 2009; Hulme, 2017; Finch *et al.*, 2021). An invasive species preparedness and management system consists of all organizations, people and actions whose primary intent is to combat the threat, spread and effects of invasive species (Williams *et al.*, 2021).

CABI's PlantwisePlus programme aims to address these challenges, in part through strengthening the capacity of national systems that are in place for not only managing invasive species outbreaks but also for preparedness and prevention. Since 2020 CABI has worked to develop a robust theoretical framework which can be used to assess the functioning of an invasive species preparedness and management system, to understand the system's capacity, strengths and weaknesses. The methodology has been tested in Kenya (Williams *et al.*, 2021) and Zambia (Constantine *et al.*, 2022a) and to some extent in Bangladesh (Constantine *et al.*, 2022b). This research builds upon this framework to assess the functioning of the invasive species preparedness and management system that is in place in Bangladesh.

Study objectives

The main objective of the study was to understand the status of the system for invasive species preparedness and management in Bangladesh. Specifically, it focussed on identifying opportunities for strengthening the invasive species preparedness and management system as a whole and developing a detailed and integrated road map for action for combating invasive species for the country across sectors.

Methodology

Two stakeholder engagement workshops were held in June and December 2023. A total of 17 institutions were represented in the workshops including central and local level representatives, and representatives from different levels of seniority. Participants included government, researchers, farmer representatives and the private sector (see Annex 1). Of these participants 13% were women. The workshops brought together key stakeholders with the purpose of assessing the current functioning of the invasive species preparedness and management system. The first workshop in June, was used as an opportunity to share the findings of the initial work that had been done in 2022 by Constantine *et al.* (2022b). Using the findings from Constantine *et al.* (2022b), participants had the opportunity to work in diverse groups to update the key findings.

The final workshop, in December, was used to:

- i) validate the findings of the assessment of the system for invasive species preparedness and management in Bangladesh, which had been initiated at the first workshop in June 2023.

ii) develop a road map for strengthening the country's system for invasive species preparedness and management. The workshop was also used as a platform to launch a call to action for all stakeholders working in agriculture, forestry and aquatic sectors to work collaboratively and intentionally towards implementing the road map for strengthening the system for invasive species preparedness and management for the country.

Workshop participants were initially identified from the list of key stakeholders and institutions and key informants from Constantine *et al.* (2022b). With this initial list, we snowballed to get names of other relevant actors and institutions across all sectors in the country. Workshop participants were engaged to validate and update the findings from Constantine *et al.* (2022b), and to subsequently quantify the functioning of the system using the methodology developed by CABI for assessing the functioning of a country's pest and invasive species preparedness and management system (see Williams *et al.*, 2021).

Findings

We present the findings of the actors, their functions and performance scoring of the invasive species preparedness and management system for Bangladesh. It should be noted that all results presented in this report reflect the consensus of stakeholders from the first workshop, which were subsequently validated by stakeholders in the second workshop.

Key actors and their functions

The country has a wide variety of actors that are part of the invasive species preparedness and management system of the country (Table 1). A total of 28 actors engage to varying degrees in delivering the ten core functions of an invasive species preparedness and management system (risk analysis, quarantine, surveillance, emergency response, diagnostic services, research/technology development, information management, advisory services, input supply, and policy and regulation) (Williams *et al.*, 2021). Table 1 further demonstrates that the invasive species preparedness and management system in Bangladesh is dynamic and multi-faceted with a wide variety of actors from different sectors, and at different levels. These actors include government agencies and bodies who are mandated with leading the development of policies and legislation; government line ministries or specialised departments within line ministries that are responsible for implementation and sub-sector oversight; regulatory bodies; local level entities including farmer organizations and community based organizations (CBOs); private sector organizations such as export companies and agro-dealers; universities and research institutes; international organizations; non-governmental organizations (NGOs); and the media.

All the actors in the invasive species preparedness and management system are multi-functional in that they have roles or are engaged in several of the core functions of the system (Table 1). Table 1 should be interpreted with this in mind: engaged or having a role in a function does not entail having responsibility for that function. This is especially evident for government line ministries, international organizations and NGOs that are engaged in almost all, if not all, functions. Similarly, local producers and farmer organizations also participate in most functions except for quarantine and policy and regulation. On the other hand, the private sector as well as research and academia are involved in fewer system functions. The private sector is largely engaged in quarantine, emergency services, information management, advisory services, input supply, and policy and regulation whereas research and academia are mostly

focused on risk analysis, surveillance, diagnostic services, information management, and policy and regulation. Government entities that focus on policy legislation are varied in their roles, but the most involvement is seen for emergency response, information management, and policy and regulation. These functions, along with risk analysis and advisory services, are also relevant for the media.

Actor performance scoring

To better understand how different actors are currently performing in delivering their roles and responsibilities within each function of the invasive species preparedness and management system, workshop participants in Bangladesh conducted and validated a performance scoring exercise. The scores were assigned based on the level of engagement and capabilities of each actor for every function, with a score of 1 indicating very limited engagement in a function or weak capacity in carrying out their role within that function and a score of 5 suggesting that the actor is very engaged in delivering a function and carries out their role and responsibilities in the highest manner. If no score is provided, then the function is not relevant to that actor (see Williams *et al.*, 2021 for full methodology). Actor scoring results from the workshops are presented in Table 2.

Table 1. Actors engaged in various functions, Bangladesh invasive species preparedness and management system.

ACTORS		FUNCTIONS									
		Risk analysis	Quarantine	Surveillance	Emergency response	Diagnostic services	Research/ technology development	Information management	Advisory services	Input supply	Policy and regulation
Government - policy legislation	Legislators, policy makers		y		y		y	y		y	y
	Crop development boards (cotton)	y		y	y	y	y	y	y	y	y
	Climate change trust fund	y			y			y	y		y
Government - line ministry	Ministry of Agriculture	y	y	y	y	y	y	y	y	y	y
	Department of Agricultural Extension (DAE)	y	y	y	y	y	y	y	y	y	y
	Department of Fisheries (DoF)	y	y	y	y	y	y	y	y	y	y
	Ministry of Environment	y		y	y	y		y	y		y
	Department of Forestry and Livestock (DOFL)	y	y	y	y	y	y	y	y	y	y
	Ministry of Health	y	y	y	y	y	y	y	y	y	y
	Ministry of Trade	y	y	y	y	y	y	y	y	y	y
Regulatory body	Pesticide control body	y	y	y	y	y		y	y		y
	Plant Quarantine Wing (PQW)	y	y	y	y	y		y	y		y
	Diagnostic labs	y	y	y	y	y	y		y	y	y
Producers / farmer organizations / local	Farmers	y		y	y	y	y	y	y	y	
	Farmer organizations	y		y	y	y	y	y	y	y	
	CBOs / IPM club	y		y	y	y	y	y	y	y	y
	Land owners			y	y	y		y	y	y	
Private sector	Export companies	y	y	y	y	y	y	y	y	y	y
	Traders	y	y		y	y		y	y	y	y
	Transporters				y					y	
	Agro-input suppliers		y		y		y	y	y	y	y
	Agro-dealers		y		y	y		y	y	y	y
Research / academia	Research	y	y	y	y	y	y	y	y	y	y
	Universities and research institutes	y		y		y		y			y
	Bangladesh National Herbarium (BNH)	y		y		y		y			
International organizations	International organizations	y	y	y	y	y	y	y	y	y	y
NGOs	NGOs	y		y	y	y	y	y	y	y	y
Media	Media	y			y			y	y		y

The results show that only 12 out of 28 total actors in the country's invasive species preparedness and management system received a score of 5 for one or more functions. Amongst these 12 actors, six of them received a score of 5 for more than half of their functions including crop development boards, Department of Agriculture Extension (DAE), Department of Fisheries (DoF), Plant Quarantine Wing (PQW), research institutes and international organizations. Consistently high ratings for these six actors possibly indicate that they are the key players that drive the country's invasive species preparedness and management system. Stakeholders in the second workshop emphasized that financial resources, particularly from national government, and the top-down policy structure of the country are important factors that enable certain actors to be more effective in carrying out their respective system functions as compared to others. Given that four of the six high-performing actors are entities of the national government (crop development boards, DAE, DoF, and PQW) and the other two (research institutes and international organizations) often support these government entities, it is likely that they have sufficient financial resources to conduct their system functions to a high level and their institutional authority allows them to play a central role in the country's invasive species preparedness and management system. As a result, stakeholders gave the majority high ratings for their system function performance. The other six actors (legislators and policy makers, Ministry of Agriculture, diagnostic labs, agro-input suppliers, agro-dealers and NGOs) received a score of 5 for at most three functions, suggesting a reasonable level of engagement in the invasive species preparedness and management system of the country but not to the same extent and performance level as the first six actors.

On the other hand, most actors within the invasive species preparedness and management system scored either a 3 (gold shading); a 2 (dark red shading) or a 1 (bright red shading). This implies that most of the actors in the invasive species preparedness and management system in the country only have a complementary role in supporting delivery of various functions (i.e., engaging in a support manner in various functions or having a specialized role within only one function). This also implies that the delivery of their role and responsibility within a function or functions in which they are engaged is perceived by stakeholders in the country as being below expectation.

Table 2. Scoring of actor performance by function, Bangladesh invasive species preparedness and management system.

ACTORS		FUNCTIONS									
		Risk analysis	Quarantine	Surveillance	Emergency response	Diagnostic services	Research/ technology development	Information management	Advisory services	Input supply	Policy and regulation
Government - policy legislation	Legislators, policy makers		2		5		3	2		2	5
	Crop development boards (cotton)	4		5	5	5	5	5	3	3	3
	Climate change trust fund	3			3			2	1		3
Government - line ministry	Ministry of Agriculture	3	3	4	5	3	3	3	3	3	5
	Department of Agricultural Extension (DAE)	5	5	5	5	5	2	5	3	4	3
	Department of Fisheries (DoF)	5	5	5	5	4	1	5	5	5	4
	Ministry of Environment	1		1	2	1		2	1		2
	Department of Forestry and Livestock (DOFL)	3	2	3	3	2	3	3	1	2	2
	Ministry of Health	4	3	4	4	4	2	3	4	2	3
	Ministry of Trade	1	3	1	3	2	1	1	1	2	3
Regulatory body	Pesticide control body	1	2	2	1	2		3	1		2
	Plant Quarantine Wing (NPPO)	5	5	5	5	5		5	2		3
	Diagnostic labs	2	3	3	5	5	5		4	2	3
Producers / farmer organizations / local	Farmers	1		2	3	2	2	3	4	3	
	Farmer organizations	2		2	3	2	3	4	3	4	
	CBOs / IPM club	2		2	3	2	1	3	4	4	2
	Land owners			2	2	2		2	2	2	
Private sector	Import / Export companies	3	4	1	4	3	1	2	2	3	2
	Traders	2	2		3	1		1	1	2	1
	Transporters				2					1	
	Agro-input suppliers	3			5		2	4	4	5	2
	Agro-dealers		1		4	4		3	5	5	2
Research / academia	Research institutes	5	2	5	5	5	5	5	5	3	4
	Universities	2	1	3	2	2	3	3	3	2	3
	Bangladesh National Herbarium (BNH)	2		1		3		2			
International organizations	International organizations	5	3	5	5	5	5	5	5	4	4
NGOs	NGOs	3		2	3	3	1	3	4	5	2
Media	Media	2			3			3	2		2

LEGEND	
	Not involved
1	Weak engagement
2	Very limited role / engagement
3	Minimally active
4	Active
5	Very active / best practice

Interaction between actors

After identifying the main actors in the invasive species preparedness and management system of Bangladesh (Table 1) and how well they perform their roles within various system functions (Table 2), the workshop participants also analysed the level of interaction between actors within the system. Several aspects of how actors interact were examined and discussed in small groups, and scores were given based on how well actors exchange information, share knowledge, coordinate, communicate, provide feedback, and whether they share funds and other resources. The results are presented in Table 3 along with the scoring criteria in the legend. In addition, workshop participants carried out an actor mapping exercise to diagrammatically show actors operating within a specific system function as well as illustrate the extent of actor interactions including actor influence and communication dynamics. Figures 1, 2 and 3 display actor maps for the system functions of emergency response, information management, and diagnostic/technology development, respectively.

Table 3 shows that all actors in the invasive species preparedness and management system of Bangladesh have some form of interaction, i.e. there are no missing interactions, with most interactions rated as either average (2) or strong (3). The strongest interactions are indicated by a rating of 4 and are seen across several clusters of actors. For example, legislators at the policy-making level of government have very strong interactions with government line ministries. Meanwhile, some government line ministries (mainly Ministry of Agriculture and Department of Agricultural Extension) have very strong interactions with each other, with farmers and farmer organizations as well as with researchers and international organizations. Farmers and farmer organizations also have very strong interactions with each other and with non-governmental organizations. Lastly, agro-input suppliers and agro-dealers have a very strong interaction with each other. The presence of very strong interactions within and between various groups of actors is encouraging because it suggests that the invasive species preparedness and management system is connected and broadly functional at national and local levels as well as across public and private sectors.

On the other hand, weak interactions are prevalent especially for farmers, CBOs, landowners and actors in the private sector including local service providers, agro-input suppliers and agro-dealers. It is interesting to note that weak interactions tend to occur with actors belonging to two groups: i) local producers, farmers and organizations and ii) the private sector. In other words, these groups are the main actors that are observed to have weak interactions with other actors in the invasive species preparedness and management system. The common connection between the two groups is that they consist of actors that mostly operate at the local level, and insights from stakeholders at the second workshop offer possible reasons for why they might have weak interactions with other actors. Actors operating at the local level are mostly small-scale entrepreneurs that face substantial direct competition, such as farmers and agro-dealers. This competition can be problematic for managing invasive species preparedness and management because limited private resources are not allocated for early prevention or detection of invasive species as this may cause loss of competitiveness. Instead, observations of invasive species tend to only be communicated to other actors when the problem is already rampant, at which point it is typically too late or too costly to address. This problem is exacerbated by low literacy rates among local actors that make it difficult for national actors such as government line ministries and researchers to transfer knowledge on

invasive species. Therefore, the weak interactions between local actors and other actors are likely due to a combination of communication that only occurs in cases of emergency and poor knowledge transfer. Strengthening these weak interactions would involve other actors developing more regular communication with local actors and investing into resources that are more easily communicable and accessible for those with low literacy rates.

The actor maps drawn by stakeholders in the workshop help to visualise the extent of interconnectedness among actors for specific system functions (see Figs 1, 2 and 3). For more visibility, certain arrows were bolded to indicate a very strong interaction between two actors using the ratings from Table 3. By combining the actor maps drawn with their interaction ratings, it becomes evident that the Ministry of Agriculture has several very strong interactions which indicates that it is a central actor in the invasive species preparedness and management system. Farmers also have several strong interactions with other actors and a very strong interaction exists between agro-dealers and agro-input suppliers. However, there is a noticeable lack of very strong interactions from agro-dealers and agro-input suppliers to other actors, particularly to the Ministry of Agriculture and farmers. Addressing this comparatively weaker interaction from these private sector actors to the Ministry of Agriculture and farmers may improve the performance of the given system function and subsequently the overall system.

Table 3. Actor interaction scoring, Bangladesh invasive species preparedness and management system.

	Legislators, policy makers	Climate change trust fund	Ministry of Agriculture	Department of Agricultural Extension (DAE)	Department of Fisheries (DoF)	Ministry of Environment	Department of Forestry and Livestock (DoFL)	Plant Quarantine Wing (PQW)	Farmers	Farmer organizations	CBOs	Land owners	Local service providers	Agro-input suppliers	Agro-dealers	Universities / research institutes	International organizations	NGOs	Media
Legislators, policy makers		2	4	3	4	4	2	4	2	2	3	2	1	1	1	3	2	3	2
Climate change trust fund	2		3	2	3	3	2	3	1	1	3	1	1	1	1	3	3	3	2
Ministry of Agriculture	4	3		4	3	3	2	3	4	4	3	2	2	3	3	4	4	3	2
Department of Agricultural Extension (DAE)	3	2	4		3	2	2	4	4	4	3	3	2	3	3	3	3	3	3
Department of Fisheries (DoF)	4	3	3	3		3	2	2	4	3	3	2	2	3	3	3	4	3	2
Ministry of Environment	4	3	3	2	3		4	2	1	2	3	1	2	1	1	2	2	3	2
Department of Forestry and Livestock (DoFL)	2	2	2	2	2	4		3	2	2	1	2	2	1	1	2	3	3	3
Plant Quarantine Wing (PQW)	4	3	3	4	2	2	3		2	2	3	2	1	2	2	3	2	3	2
Farmers	2	1	4	4	4	1	2	2		4	4	1	3	3	3	3	2	4	2
Farmer organizations	2	1	4	4	3	2	2	2	4		4	1	3	3	3	3	2	4	2
CBOs	3	3	3	3	3	3	1	3	4	4		2	3	2	2	1	3	1	2
Land owners	2	1	2	3	2	1	2	2	1	1	2		3	1	1	2	2	2	1
Local service providers	1	1	2	2	2	2	2	1	3	3	3	3		2	2	1	2	1	2
Agro-input suppliers	1	1	3	3	3	1	1	2	3	3	2	1	2		4	2	1	2	2
Agro-dealers	1	1	3	3	3	1	1	2	3	3	2	1	2	4		2	1	2	2
Universities / research institutes	3	3	4	3	3	2	2	3	3	3	1	2	1	2	2		3	2	2
International organizations	2	3	4	3	4	2	3	2	2	2	3	2	2	1	1	3		3	3
NGOs	3	3	3	3	3	3	3	3	4	4	1	2	1	2	2	2	3		2
Media	2	2	2	3	2	2	3	2	2	2	2	1	2	2	2	2	3	2	

LEGEND	
0	no interaction
1	weak interaction
2	average
3	strong interaction
4	very strong interaction

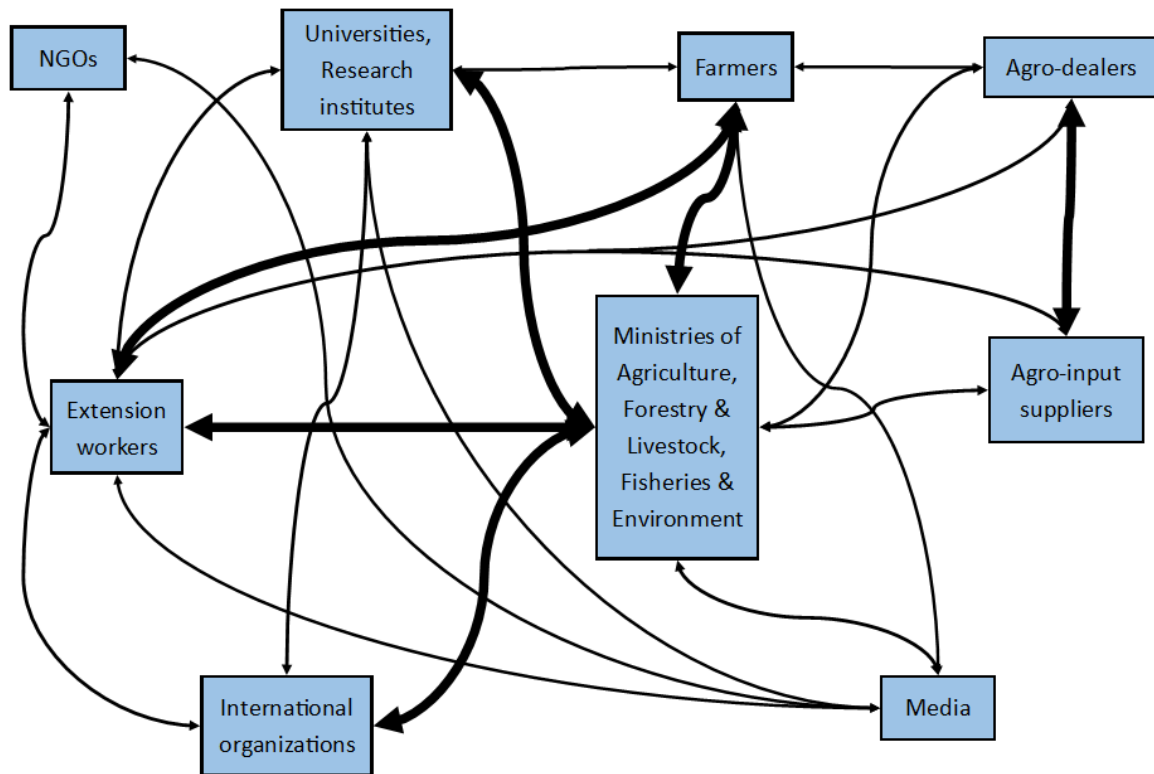


Fig. 1. Actor map, Emergency response function, Bangladesh. Bolded arrows indicate very strong interaction.

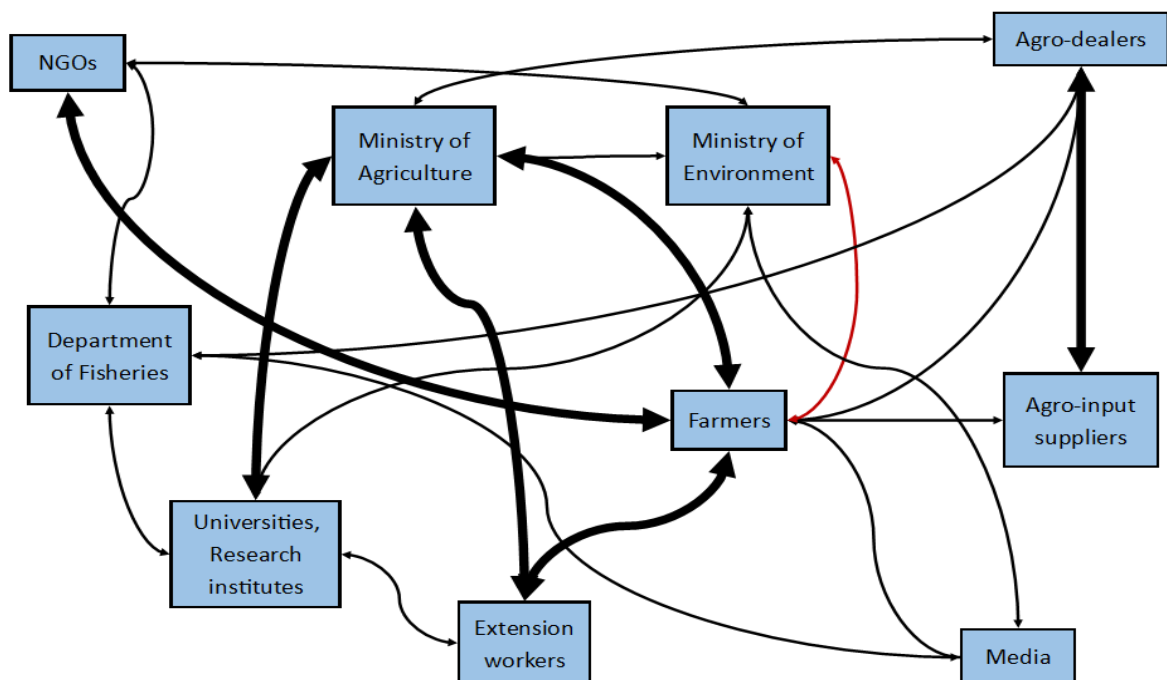


Fig. 2. Actor map, Information management function, Bangladesh. Bolded arrows indicate very strong interaction. Red arrow indicates weak interaction.

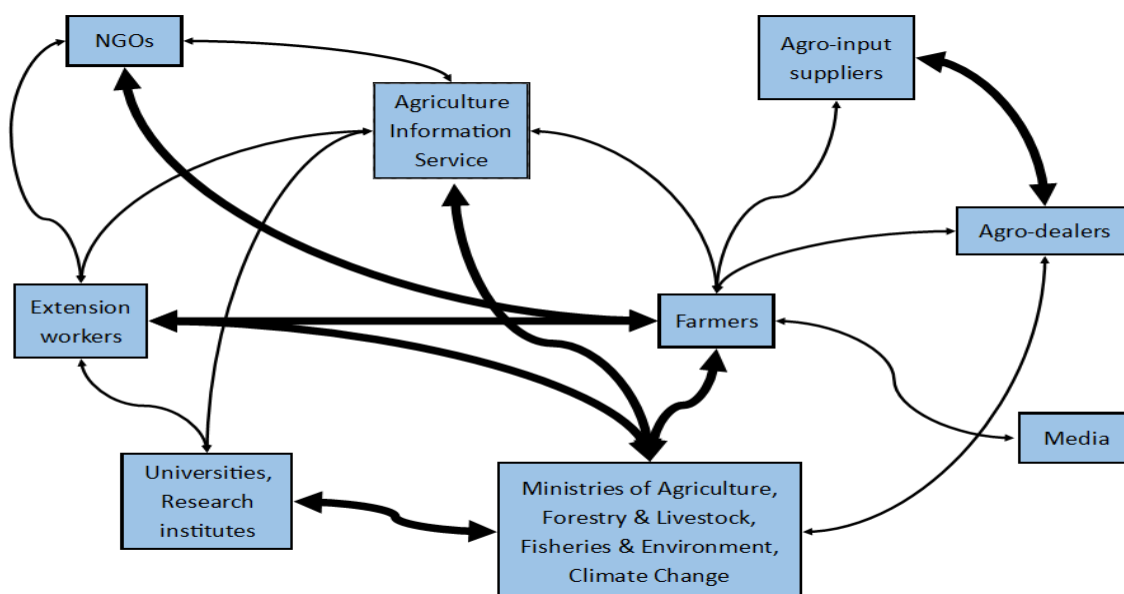


Fig. 3. Actor map, Diagnostic/technology development, Bangladesh. Bolded arrows indicate very strong interaction.

System performance scoring

After assessing the performance of actor functions and actor interactions, the performance of the overall invasive species preparedness and management system of Bangladesh is analysed in three steps. First, each system function is measured for its overall performance against a set of system level indicators as well as a set of contextual factors (Table 4). The conceptualisation and definitions from Williams *et al.* (2021) are used for the system level indicators (availability; access; coverage; acceptability; timeliness; affordability; and sustainability) and the contextual factors (finance; staffing; governance; and communication). Scores are provided for indicators that are relevant to the given function of the invasive species preparedness and management system. Second, the outputs of the invasive species preparedness and management system – prevention, detection and control (Williams *et al.*, 2021) – are measured for their performance against the set of system level indicators (Table 5). Finally, the same outputs are measured against the contextual factors (Table 6).

Risk analysis, quarantine, surveillance and diagnostic services functions have scores of 2 across the board for all performance indicators (Table 4). This result implies that, for all four functions, there is an awareness of their importance in managing invasive species in the country, but they are not being effectively delivered. Scores of 2 also imply that facilities and resources to carry out the functions are few with limited links to structures on the ground. As a result, the four functions provide some appropriate solutions, but in most cases, solutions are infeasible or inappropriate for farmers and other land users to implement (e.g. solutions are more relevant to commercial growers).

Table 4. Scoring of performance indicators by function, Bangladesh invasive species preparedness and management system.

FUNCTIONS	Performance Indicator					Contextual Factors			
	Availability, access, coverage	Acceptability	Timeliness	Affordability	Sustainability	Finance	Staffing	Governance	Communication
Risk analysis		2	2		2	2	2	3	3
Quarantine	2	2	2	2	2	2	2	2	2
Surveillance	2	2	2	2	2	2	2	2	2
Emergency response	3	3	3	3	3	3	3	3	3
Diagnostic services	2	2	2	2	2	2	2	2	2
Research and technology development	3	3	2	3	3	3	3	3	3
Information management	3	3	2	3	3	3	2	3	3
Advisory services	3	3	3	3	3	3	3	3	3
Input supply	3	3	3	3	3	2	2	3	3
Policy and regulation	3	3	2	2	3	3	2	3	2

LEGEND	
1	Weak or non-existent
2	Limited, developing
3	Adequate
4	Sufficient
5	High quality, strong or high priority

In addition, the functions are delivered in a delayed manner with solutions for managing invasive species often not available when required by farmers and other land users. Lastly, a score of 2 implies that some provisions are made with limited financial resources available for carrying out the four functions which suggests that, although all functions are carried out in-country, there is still dependency on external support in these areas for managing invasive species in the country.

The low scores for these functions is somewhat surprising given that certain key organizations, mainly government line ministries and regulatory bodies, are considered to be executing their roles in these functions at the highest level (see Table 2). However, a possible reason for the overall system to receive a low score could be related to weak stakeholder interactions, particularly at the local level (see Table 3). As previously mentioned, local actors such as producers, farmers, farmer organizations and the private sector tend to communicate with each other only in cases of emergency. The lack of communication makes it difficult to effectively carry out risk analysis, quarantine, surveillance and diagnostic services functions in the field, even if government line ministries are conducting their roles at the highest level. Furthermore, although interactions between government line ministries and farmers are indicated to be strong (see Fig. 3), the problem of communication is exacerbated by the fact that low literacy rates often limit top-down knowledge transfer from government to local actors, especially farmers. These barriers are possible reasons as to why government line ministries are seen to perform diagnostic functions well while the overall system still performs poorly.

On the other hand, emergency response, advisory services and input supply have scores of 3 across the board for all performance indicators, suggesting that these three functions are given some importance. For example, a score of 3 for availability, access and coverage states that facilities and resources are present at a few strategic locations and that there are some links to extension to ensure that needs on the ground are met. For acceptability, the three functions generally provide some appropriate solutions for farmers and other land users to implement. For timeliness, the functions are carried out and made available to the population in need with some, but not extensive, delays. For affordability, provisions are made to ensure that funds are sufficient for carrying out the three functions, but amounts of actual financial resources are available only on a small-scale. And for sustainability, the functions occur in-country with some external support in their delivery. The functions of research and development as well as information management also have scores of 3 except for the performance indicator of timeliness, implying delayed delivery despite otherwise adequate performance. Additionally, the policy and regulation function also have scores of 3 except for indicators of timeliness and affordability, suggesting delayed delivery as well as limited financial resources and potentially some dependency on external support.

Looking at the contextual factors of Bangladesh that affect the invasive species preparedness and management system functions (Table 4), half of the functions have adequate finances to deliver most function outputs while the other half are considered to have limited finances. The staffing of system functions is worse, with only three functions (emergency response, research and development, and advisory services) considered to have adequate staff. On the other hand, the governance of system functions is better, with seven functions given an adequate rating. And the communication for six functions is considered adequate. Despite the overall adequate ratings, it should be noted that three functions have consistent ratings of 2 for the contextual factors: quarantine, surveillance and diagnostic services. This result implies that these functions only have limited finance and staff available that enables delivery of basic function outputs. In addition, there is limited leadership to give direction in delivering the basic function outputs, and this is accompanied by limited communication between actors. The system functions of risk analysis and input supply also have limited finance and staffing while the policy and regulation function has limited staffing and communication. For policy and regulation, limited staffing can affect the articulation of policies and regulations that govern invasive species management which can result in poor execution at the implementation level, and Constantine *et al.* (2022a) reports that this problem is evident in Bangladesh. Lastly, the information management function has limited staffing which can be attributed to the need for specialised training and skillsets to deliver basic function outputs.

After scoring the performance of system functions, stakeholders assessed the outputs – prevention, detection and control – of the invasive species preparedness and management system in Bangladesh. The outputs are measured using the same five performance indicators as the system functions, but an additional indicator of coherence is also included (Table 5).

Table 5. System performance scoring, Bangladesh invasive species preparedness and management system.

OUTPUTS	Performance Indicator					Coherence
	Availability, access, coverage	Acceptability	Timeliness	Affordability	Sustainability	
Prevention	2	2	2	2	2	2
Detection	2	2	1	2	2	2
Control	2	2	2	2	2	2
Overall System	2	2	2	2	2	2

LEGEND	
1	Non-existent
2	Available but inadequate
3	Adequate
4	Sufficient
5	High quality, excellent, clear

For all outputs across all indicators except one, the stakeholders gave a score of 2 to state that the invasive species preparedness and management system in Bangladesh exists but is inadequate in all areas. The one exception is the timeliness of the detection output, which stakeholders considered non-existent, that is, invasive species are never detected in a timely manner. The latter result supports the previous finding that local actors typically do not report issues with invasive species until the problem is already rampant. However, the consistent scores of 2 across all other indicators for all outputs is somewhat surprising given that stakeholders provided positive to neutral ratings for actor function performance, actor interactions, and even some system functions. In other words, despite the stakeholders considering the performance of specific actors and functions to be sufficient or even strong, there is a strong consensus that the invasive species preparedness and management system has considerable room for improvement before it can adequately prevent, detect and control invasive species in Bangladesh.

Finally, stakeholders assessed the contextual factors of the system outputs (see Table 6). For the prevention and control outputs, scores of 3 were provided for all factors. This result suggests that the current level of finances, staffing, governance and communication allows adequate prevention and control of invasive species in Bangladesh. However, for the detection output, stakeholders provided scores of 2 for all contextual factors, suggesting that current levels of resources (finance, staffing, governance and communication) hinder effective detection of invasive species. Overall, there is much room for improvement before any of the contextual factors of the invasive species preparedness and management system in Bangladesh are perceived as being sufficient or even excellent, a finding which is supported by Constantine *et al.* (2022a).

Table 6. Scoring of system performance indicators against contextual factors, Bangladesh invasive species system.

OUTPUTS	Contextual Factors			
	Finance	Staffing	Governance	Communication
Prevention	3	3	3	3
Detection	2	2	2	2
Control	3	3	3	3

LEGEND	
1	Non-existent
2	Available but inadequate
3	Adequate
4	Sufficient
5	High quality, excellent, clear

Recommendations and next steps

Participants of the stakeholder workshops agreed on next steps that need to be enacted in order to strengthen the invasive species preparedness and management system in the country as follows:

- *Establish a national coordination body:* A coordinating body acting as a national task force (NTF) should be formed. It should be a multi-sectoral task force that oversees all national invasive species preparedness and management issues such as the implementation of a National Action Plan across the sectors of agriculture, forestry and fisheries. It should work closely with the respective government line ministries of each sector and be co-managed by other key actors including Bangladesh Agricultural Research Council (BARC) and other members of the National Agricultural Research System (NARS), Department of Agriculture Extension (DAE), universities, private sector and non-governmental organizations (NGOs). It should focus on strengthening quarantine, functional surveillance and monitoring.
- *Capacity building:* There is need for more efforts to build capacity for pest and invasive species assessment and management, within sector and across the country. This should include capacity building of staff working in various sectors on various topics including the use of digital tools and improving diagnostic skills. For long term changes, there is need to incorporate curricula on pest and invasive species diagnosis, control and management in university training. Finally, there is also need for funds to support collaboration and networking of scientists for example for research, as well as regional and international networking.
- *Infrastructure development:* There is need to upgrade national laboratories, while concurrently strengthening regional laboratories and quarantine stations.
- *Update invasive species lists:* There is need to update the national invasive species list. This should go together with documenting native natural enemies as well as conducting research to determine current levels of loss, in different sectors, as a result of invasive species. The invasive species list should also include potential pests from neighbouring countries or ports of entry that may cause various sectors to incur losses.

Surveillance and monitoring resources can conduct pest risk analysis and horizon scanning as well as interact with other countries to prevent the entry of such potential invasive species.

- *Communication and media*: Need for communication campaigns aimed at creating awareness amongst the public around different invasive species and their management options. This would include large scale media coverage but also local level community engagement.
- *Ringfencing of finances, by different sectors*: To support strengthening of the invasive species preparedness and management system. These funds can be used for different key actions including launching media campaigns, supporting regional and international networking and collaboration of scientists across various sectors, and can be used to develop sustainable management options for prioritised invasive species.

Many of these recommendations have been taken forward by the stakeholders and are included in a National Action Plan as presented below.

Study limitations

Limitations of the study include:

- The methodology could be improved by building a stronger connection from the actors and functions performance to the overall system performance. There were some inconsistencies in the results in which certain actors or functions were indicated to perform well, but the overall system performance was quite low. While possible explanations are offered, a clearer development from individual actors and single functions to overall system coherence would hopefully offer more consistent and robust results.
- The representation of stakeholders in the second workshop consisted entirely of government ministries and academics. This disproportionate representation could have potentially affected the validation of performance results of local actors such as farmers, community-based organizations, agro-dealers, and so forth. More inclusion of local stakeholder groups would allow for a wider view of perspectives with potentially different outcomes for the study.

National Action Plan

On the last day of the second workshop in December 2023, stakeholders produced a National Action Plan (Table 7) to enhance the invasive species preparedness and management system of Bangladesh. The action plan listed key tasks under the three outputs of prevention, detection and control and identified institutions that would be responsible for conducting those tasks. Each task was given a priority level (high, medium, low) and a target completion of 2030 or earlier to indicate whether the task was a medium- or long-term effort. The action plan also determined the necessary resources and appropriate budget to implement the tasks along with additional notes as needed.

It should be noted that the main institutions that will be responsible for carrying out most of the action plan are the government line ministries of Department of Agricultural Extension (DAE), Department of Environment (DoE), and Department of Fisheries (DoF). Each department is responsible for implementing the tasks for their respective sectors of agriculture, forestry and

aquaculture. The amount of responsibility given to these institutions highlights the central role that government ministries play in managing the invasive species preparedness and management system of the country, and how the combination of the top-down policy structure along with financial resources from the government supports the significant influence of these departments. Other responsible institutions will likely support the government ministries in these tasks.

Table 7. National Action Plan for system enhancement (2024–2030), Bangladesh invasive species preparedness and management system.

Action / task	Institution responsible	Priority level	Target completion date	Status	Resources needed	Budget (BDT)	Notes
PREVENTION							
1. Strengthening of Plant Quarantine Wing (PQW) and Plant Protection Wing (PPW)	Govt line ministries*, universities	High	2030	Medium/long	Lab facilities, instrument, training, consumables	90 million	Crop
2. Skilled manpower	DAE	High	2026	Medium/long	International expert, university faculties, internal expert, researcher	30 million	
3. Lab development	Universities, research insitutes, PQW	High	2025	Medium/long	Lab equipment, international collaboration	20 million	
4. Formation of National Task Force	Govt line ministries, universities	High	2024	Medium	Resource personnel	2.5 million	
5. Awareness creation	Govt line ministries, universities, mass media	Medium	2026	Medium/long	Funding, booklet, manual, radio, TV (mass media)	10 million	Workshop, training, media, booklets, brochures
6. Field activities & strong interactions with neighbouring countries	Govt line ministries, Climate Change Trust Fund	Medium	2025	Medium/long	Appropriate surveillance and monitoring protocol	5 million	
7. Unified policy making	Govt line ministries	Low	2026	Medium	Experts	2 million	
DETECTION							
1. Development of surveillance protocol & skilled manpower for monitoring	Govt line ministries	High	2026	Medium	Training, workshop, symposium	10 million	
2. Assessment of invasive species spread	Govt line ministries, universities, research institutes	High	2026	Medium	Software, tablets, fuel	8 million	
3. Formation of community-based organizations (CBOs)	Govt line ministries	Medium	2025	Medium	Vehicles, fuel, allowances	25 million	
4. Training and workshop for detection purposes	Govt line ministries, universities, research institutes	Medium	2026	Medium	Resource personnel	6 million	
5. GIS modeling for tracking	Govt line ministries	Low	2025	Medium	Software, drone, skilled personnel	60 million	
CONTROL							
1. Technology development and dissemination	Govt line ministries, universities, mass media	High	2030	Long	Input, physical facilities, capacity development, training	15 million	
2. Input supply	Govt line ministries, NGOs, farmers organizations	Medium	2030	Long	Materials, inputs, manpower, specialists	20 million	
3. Incentive for collecting invasive species	Govt line ministries, NGOs	Medium	2026	Long	Money, tax break	10 million	
4. Formulation of animal feed (aquaculture)	DoF	Low	2030	Long	Equipment	10 million	
5. Collection of invasive species	Govt line ministries	Low	2024	Medium	Equipment	5 million	

*Govt line ministries = Department of Agricultural Extension (DAE), Department of Environment (DoE), and Department of Fisheries (DoF)

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Annex

Annex 1. Institutions represented at stakeholder engagement workshops

Name of Organization / Project

Ministry of Agriculture

Ministry of Environment, Forests and Climate Change

Department of Fisheries (DoF) under the Ministry of Fisheries and Livestock (MoFL)

Plant Quarantine Wing (PQW) of the Department of Agriculture Extension (DAE)

Plant Protection Wing (PPW), DAE

Entomology Division, Bangladesh Agricultural Research Institute (BARI)

Faculty of Fisheries, Bangladesh Agricultural University (BAU)

Department of Agronomy, BAU

Department of Forestry and Environment, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU)

Department of Plant Pathology, BSMRAU

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