EARLY WARNING AND RAPID RESPONSE SYSTEM FOR PESTS AND DISEASES IN GHANA

Technical Report

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About AICCRA Reports

Titles in this series aim to disseminate interim research on the scaling of climate services and climate-smart agriculture in Africa, to stimulate feedback from the scientific community.

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About AICCRA

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1.0 INTRODUCTION

1.1 BACKGROUND

An early warning and rapid response system for pests and diseases (EWRRS-PD) is crucial for ensuring food security and protecting agricultural livelihoods. In Ghana, where agriculture is a major contributor to the economy, the impact of pests and diseases can be devastating. The main drivers of plant pests and diseases spread include trade, climate change and socio-economic developments. The development of such an EWRRS-PD can help farmers and agricultural stakeholders to detect and respond to outbreaks quickly, minimizing the damage caused by pests and diseases. This system can also provide valuable data for decision-makers to develop effective policies and strategies to prevent future outbreaks. In this context, the development of an early warning and rapid response system for pests and diseases in Ghana is a critical step towards achieving resilient agri-food systems.

1.2 SITUATIONAL ANALYSIS

In Ghana, several response mechanisms are in place for plant pests and diseases outbreaks. These mechanisms involve collaboration between government agencies, universities, research institutions, developmental partners and local stakeholders to monitor, detect, predict, and respond to pests and diseases affecting crops. Some of the key response mechanisms include:

- ***Ghana Emergency Response Plan for Invasive Alien Plant Pests:*** The Plant Protection and Regulatory Services Directorate (PPRSD) of the Ministry of Food and Agriculture (MoFA) Ghana has developed a response plan to address invasive alien plant pests. This EWRRS-PD materializes one of the core elements of the existing PPRSD-led Ghana Emergency Response Plan for Invasive Alien Plant Pests.
- ***Integrated Pest Management (IPM):*** IPM has emerged as a sustainable approach to the prevention and control of pests and diseases that attack crops. IPM uses natural enemies of pests and biopesticides as potential solutions, producing fewer health and ecological problems than the use of synthetic pesticides.
- ***One Health Platform for Climate-Driven Pests and Diseases:*** AICCRA is working with scientists, public and private sector partners to develop a One Health Platform for climate-driven pests and diseases in Ghana. This platform aims to enhance the health of plants, animals and their shared environment by recognizing their interconnectedness.
- ***The National Disaster Management Organization (NADMO)*** in Ghana collaborates with PPRSD in responding to plant pests and diseases outbreaks.
- ***The United States Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS)*** coordinates animal and plant disease and pest response in natural disasters in Ghana. These organizations work together to ensure that the country is prepared to respond to plant pest and disease outbreaks and minimize their impact on the agricultural sector.
- ***The Centre for Agriculture and Biosciences International (CABI)*** developed and deployed the Horizon Scanning Tool as an essential decision support aid that plays a significant role in early warning and rapid response to plant pests and diseases. This tool utilizes CABI data to generate a list of species that are not recorded as present in a selected 'area at risk' but are reported from 'source areas' with similar climates, neighbouring areas, or selected trading partners. By identifying potential invasive species threats to a country, state, or province, the tool helps in proactively assessing and mitigating the risk of pests and diseases outbreaks. The Horizon Scanning Tool is particularly valuable for risk assessors, plant protection officers, Phytosanitary Inspectors, and other relevant stakeholders involved in biosecurity and plant health management. Furthermore, the tool links to corresponding invasive species datasheets, providing users

with comprehensive information to support informed decision-making and response planning. Overall, the CABI Horizon Scanning Tool contributes to improving biosecurity, guiding resource allocation, and enhancing preparedness and response to plant pests and diseases, thereby playing a crucial role in safeguarding agricultural and environmental health. This tool will form a crucial part of the EWRRS-PD being developed for Ghana.

- ***National Framework for Climate Services (NFCS):*** This is crucial to the development and implementation of an EWRRS-PD in Ghana. The NFCS managed by the Ghana Meteorological Services (GMet) provides climate information services that are essential for the development of climate-smart agriculture and the management of pests and diseases. The NFCS provides the necessary climate information to support the EWRRS, enabling the system to anticipate and respond to climate-driven pests and diseases. The NFCS is, therefore, a critical component of the EWRRS, providing the necessary information to support decision-making and response planning for plant pests and diseases outbreaks in Ghana.
- ***Ag-Data Hub:*** The Ag-Data Hub serves as a centralized platform for collecting, analysing, and disseminating agricultural data, including information on pests and diseases prevalence, climate conditions, and predictive modelling. This data-driven approach enables stakeholders to make informed decisions and take proactive measures in response to potential pest and disease outbreaks. By providing access to real-time and historical data, the Ag-Data Hub enhances the capacity for early detection, monitoring, and prediction of pests and diseases threats, thereby supporting timely and targeted response efforts. Additionally, the hub facilitates collaboration among various relevant stakeholders, including farmers, researchers, academia, and government agencies, to strengthen the resilience of Ghana's agricultural sector against the impacts of plant pests and diseases.

These response mechanisms demonstrate the ongoing efforts to address plant pests and diseases outbreaks in Ghana and protect the country's agricultural sector. Furthermore, existing partnerships with local relevant stakeholders and international institutions are crucial for the operationalization and implementation of the EWRRS.

The Ghana Cluster of the Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) project, led by the International Institute for Tropical Agriculture (IITA) and its partners are working on an Early Warning and Rapid Response System for Pests and Diseases (EWRRS-PD) to enhance communication, data sharing, and preparedness against new risks. Following several preparatory meetings, a workshop was held to validate a partnership agreement between eleven public and private sector institutions whose core mandate relates to the subject. This validation workshop was followed by a signing ceremony where heads of the partner institutions demonstrated their commitment to this cause by signing the Memorandum of Understanding (MOU). This commitment is a testament to the importance placed on an EWRRS-PD in Ghana. The AICCRA Ghana Cluster is also leading capacity building for relevant stakeholders in reporting, risk knowledge generation, risk communication, monitoring and warning, risk assessment, and risk response dissemination.

This situational analysis highlights the ongoing efforts to improve plant pests and diseases surveillance in Ghana and underscores the potential for collaboration in developing an effective EWRRS-PD in Ghana.

1.3 SCOPE of the EWRRS-PD

The scope of this EWRRS-PD encompasses several key aspects and efforts to enhance early warning alerts, strengthen monitoring and detection, and promotes a collaborative, data-driven, and climate-smart approach to effectively address the challenges posed by pests and diseases outbreaks. The key elements shall include:

- ***Enhanced Early Warning and Rapid Response:*** The system aims to enhance early warning alerts and rapid response to pests and diseases, ensuring that adequate intervention and control measures are put in

place for timely detection of any pest or disease outbreak and adequately protect crops from their harmful effects.

- ***Monitoring, Detection, Prediction, and Warning Alerts:*** The system will focus on strengthening the monitoring, detection, prediction, and warning alerts for pests and diseases, addressing the weaknesses in existing systems to prevent invasive alien species (IAS) from going undetected until they become endemic and spread quickly.
- ***Collaborative and Climate-Smart Response:*** The system will offer a collaborative and climate-smart response to the challenges posed by variations in climate conditions, allowing pests to spread and survive in new environments, creating more problems for farmers.
- ***Data-Driven Approach:*** The system will leverage a data-driven approach, utilizing agricultural data, climate information, and predictive modelling to support early detection, monitoring, and prediction of pests and diseases threats, thereby enabling timely and targeted response efforts.
- ***Stakeholder Commitment and Collaboration:*** The system will leverage on and involve the commitment and collaboration of various relevant stakeholders in the agriculture sector, including government agencies, universities, research institutions, and technology solutions institutions, to develop and implement robust mechanisms for early control and management of pests and diseases.

2.0 THE EWRRS-PD AUTHORITY

International Conventions and Agreements ratified and signed by Ghana together with the national legislative laws that provide the legal basis for PPRSD to carry out its functions as they relate to outbreaks response activities include:

- Plants and Fertilizer Act, 2010 (Act 803)
- Plant Protection Regulations, 2012 (L.I. 2193)

These national legislative laws mandate the directorate to carry out pest surveillance, determine pest status in an area, adopt appropriate phytosanitary measures, protect endangered areas, report outbreaks of plant pests and, when appropriate, confirm pest eradication. PPRSD is recognised as the National Plant Protection Organization (NPPO) by the International Plant Protection Convention (IPPC) and as official contact point for Plant Health and the National Enquiry Point (NEP) for the World Trade Organisation Sanitary and Phytosanitary (WTO-SPS) Agreement.

The national legislative laws mandate the PPRSD to perform the following specific functions:

- Authorises the officers of the directorate and other authorized persons to enter premises, conveyances and other places where imported commodities, regulated pests or other regulated articles may be present, inspect or test imported commodities and other regulated articles, and take and remove samples from imported commodities or other regulated articles, or from places where regulated pests may be present.
- Defines the roles and responsibilities of international, national and regional institutions and other relevant stakeholders who support the directorate in delivering its mandate related to the identification of pest status and the establishment and update of the list of commodities, quarantine, calamity, newly introduced and regulated plant pests and diseases.
- Declares an area as infested or subject to quarantine, and to adopt measures to eradicate or contain the spread of endemic and newly introduced pests and diseases.
- Describes regulatory controls to restrict the movement of certain plants, plant products and regulated articles within areas of Ghana, including within buffer zones.
- Implements emergency phytosanitary measures to prevent the introduction, establishment and spread of alien invasive species.

- Allows diagnostic facilities to be established and maintained or give access to appropriate up-to-date diagnostic services to ensure that pests and diseases are properly identified.
- Ensures mandatory domestic reporting to the NPPO on the detection or suspected presence of regulated pests/diseases, and pests/diseases new to an area, host or pathway.
- Authorises a designated officer to eradicate a pest/disease or prevent the spread of a pest/disease after a pest risk assessment and suspects that a plant, plant product or regulated article is suspected to be a pest/disease, could be infested or a biological obstacle to the control of a pest/disease.
- Conducts specific surveys (detection and delimiting surveys) to establish Pest Free Areas (PFAs), Pest Free Places of Production (PFPP), Pest Free Production Sites (PFPS) or Areas of Low Pest Prevalence (ALPP) in line with the required International Standard for Phytosanitary Measures (ISPMs).
- Carry out surveillance of growing plants and plant products in storage or in transit to report pests outbreaks, spread and the control of the pests or diseases.

Based on these international conventions, Agreements and legislative laws, the PPRSD is best suited to serve as the EWRRS-PD Authority. The Authority shall serve as the central coordinating unit and host the secretariat of the EWRRS-PD. The Director of PPRSD shall be the head of the Authority and shall appoint a National, Regional and District Focal Persons. The Director of PPRSD shall be a member of the Steering Committee and the National Focal Person shall serve as the Secretary to the Steering Committee.

3.0 PRINCIPLES

The EWRRS-PD Plan has been developed based on the following principles:

- Preventing the introduction of alien invasive species is the most cost-effective method for their management.
- Immediate eradication is the primary goal for rapid response but containment, or a long-term strategy to sustainably manage, may be necessary for widely established populations of destructive pests.
- Risk assessments provide valuable information concerning the potential threat of new invasive species to the country, which will help determine the resources and management actions required for a successful response.
- Rapid response will employ procedures to achieve specific objectives for managing target species while minimizing adverse effects on environmental, economic and human values.
- Effective EWRRS-PD depends upon timely intervention. However, some species that pose extreme danger may require immediate intervention.
- Regardless of PPRSD being the governmental agency mandated to handle issues of invasive species introduced into the country, successful EWRRS-PD requires multi-sectorial approach involving government institutions, development partners, non-governmental organizations, private sector and the community.
- Public and community involvement are essential for timely and effective EWRRS-PD. Public support for EWRRS-PD actions and management is important to the success of EWRRS-PD in a country.

4.0 PARTNERS AND THEIR IMPORTANCE TO THE EWRRS-PD

4.1 Plant Protection and Regulatory Services Directorate (PPRSD)

As the NPPO of Ghana with legal mandate outlined in section 3, PPRSD shall play a lead role and serve as the EWRRS-PD Authority.

4.2 Biotechnology and Nuclear Agriculture Research Institute (BNARI)

The BNARI was established with the mandate to exploit biotechnology and nuclear science applications for sustainable agriculture solutions. The institute has developed capacity in pest and disease surveillance, integrated pest and disease management and the development of new tools against pests and diseases. As a co-lead on the EWRRS-PD, BNARI shall be involved with pests and diseases surveillance, pest risk assessment and the development of response plan alongside other knowledge institutions. Having expertise in research and development of climate smart one-health solutions, BNARI shall ensure the one-health compliance of the EWRRS-PD.

4.3 Centre for Scientific And Industrial Research-Institute For Scientific And Technological Information (CSIR-INSTI)

The mandate of the CSIR-INSTI as established is to develop a national capacity and capability for efficient and effective provision of scientific and technological information on demand, for the benefit of research scientists, policy makers and industrialists in appropriately packaged form for national development. It is the lead institution involved with the development, implementation and hosting of the Ag-Data Hub; a tool that is central to the EWRRS-PD as outlined in section 1.2 above.

4.4 Centre for Scientific and Industrial Research-Crop Research Institute (CSIR-CRI)

The CSIR-CRI has a broad research mandate covering all food and industrial crops, with a mission to develop and disseminate demand-driven technologies and build capacity for sustainable food and industrial crops productivity to enhance livelihoods. Based on this mandate, it is involved as a knowledge institution and shall be involved with pest and disease surveillance, pest risk assessment and the development of response plan alongside other knowledge institutions.

4.5 Centre for Scientific and Industrial Research CSIR-Savannah Agricultural Research Institute (CSIR-SARI)

The mandate of the CSIR-SARI is to provide farmers in the northern savannah regions with appropriate technologies to increase their food and fibre crop production based on a sustainable production system which maintains and/or increases soil fertility. Based on its experience with the savannah agriculture systems and their strategic location CSIR-SARI shall be responsible for pests and diseases knowledge activities in the savannah regions on the EWRRS-PD.

4.6 Ghana Meteorological Agency (GMet)

The GMeT is a governmental agency under the Ministry of Communication mandated to offer weather and climate services, to analyse scientific research findings and provide guidance on climate change. The GMeT is the lead institution for Ghana's National Framework for Climate Services. Considering that most of the pests and diseases challenges we face are climate driven and the active role of GMeT in the development and implementation of the Ag-Data Hub, it shall be involved with the provision of climate information services for the EWRRS-PD.

4.7 National Disaster Management Organisation (NADMO)

The mandate of NADMO includes all activities from preparedness to response and recovery, prevent disasters, create awareness in prone communities and institutions on all hazard/disaster types, train and motivate the communities especially volunteers to initiate actions to prevent and respond to disasters; bring relief to

disaster victims, assist to reduce poverty in vulnerable and poor communities through social mobilisation for employment creation and income generation. The NADMO is onboard the EWRRS-PD with its expertise in risk forecasting, analysis and management as well as preparedness to response and recovery.

4.8 University for Development Studies (UDS)

The UDS represents the universities on the EWRRS-PD as a knowledge institution responsible for risk confirmation and development of response tools and advisory. The UDS hosts the West African Centre for Water, Irrigation and Sustainable Agriculture (WACWISA) which was established with the mission to develop skills and knowledge of young men and women to provide practical and sustainable solutions to the challenges of water resources, irrigation, agricultural development and climate change in Africa.

4.9 Local Government Service- Directorate of Agriculture Extension Services (DAES)

The DAES is responsible for the overseeing of agricultural technology diffusion through the management of an extension delivery service in the country. They work closely with all the key players in knowledge generation and communication and are directly in touch with farmers at the community level. The DAES shall be responsible for communication of pests and diseases risk information, response and advisory as well as training of farmers on risk detection and response implementation.

4.10 Farmerline

Farmerline is a private e-extension services company working to give growers access to quality inputs, training and markets, tools they can translate into sustainable, healthy incomes. On the EWRRS-PD, Farmerline shall work closely with the DAES and other stakeholders in pests and diseases risk information communication and use their networks to disseminate response information.

4.11 Environmental Protection Agency (EPA)

The mission of the EPA is to manage, protect and enhance the country's environment and seek common solutions to global environmental problems. It is responsible for registration, control, management and regulation of pesticides in Ghana and, collaborates with PPRSD to enforce the pesticides law. The EPA shall regulate and provide advisory on pesticides and other related matters for the EWRRS-PD and shall ensure environmental compliance of all surveillance and response activities.

5. ORGANIZATIONAL STRUCTURE FOR THE EWRRS-PD

The EWRRS-PD shall be a network of independent elements working together to achieve a common goal, “To detect new pest and disease outbreak situations early and to act quickly”. It aims to establish a national early warning coordination capability for pests and diseases. The EWRRS-PD shall have designated positions and established committees, as necessary, to provide system coordination and leadership. The organizational structure shall consist of:

A. Steering Committee

This committee shall be the highest decision-making body of the EWRRS-PD. The committee shall be composed of the heads of the 11 partner institutions listed in section 4. The roles of the committee will be:

- receive reports and recommendations from the EWRRS-PD authority and take decisions accordingly.

- source for funds for implementation of programs of the authority.
- approve programs of the EWRRS-PD authority.

B. Early Warning and Rapid Response Authority

The Early Warning and Rapid Response Authority / National Focal Point, shall be made up of staff of NPPO (PPRSD) chaired by the Director. The roles of the authority shall include:

- creating a network of high-level experts to process the collated data, identify the threat, continuously monitor, and provide updates on the potential threats.
- establishing a multi-sectoral working group to facilitate decision-making and policy influence.
- providing mechanisms to facilitate the implementation of recommendations.
- coordinate the activities of risk knowledge generators and communicators.

To be able to discharge its mandate, the authority may establish a Technical Committee made up of experts on invasive species matters, weather forecasters, taxonomists and other areas relevant for managing Invasive Alien Species (IAS), from the institutes stated in section 4 and from other Research Institutes and Universities in Ghana. The committee shall include risk knowledge generators (NARS, Academia, International researchers, Agric NGO's) and risk communicators (CSIR-INSTI, Ag-Hub data, NADMO, Farmerline, GMet, DAES/MOFA).

The technical committee shall be tasked with the following roles:

- Maintaining the EWRRS-PD Plan and updating it from time to time when necessary.
- Developing program procedures, deliverables, templates, and reporting
- Determining risk-ratings for new invasive species with consideration of recommendations from the PPRSD District and Regional Focal Persons
- Review the updates and reports from the PPRSD District and regional Focal persons.
- Approve annual EWRRS-PD program deliverables.
- Evaluate and recommend revisions to the EWRRS-PD process.
- Train the regional/district EWRRS-PD Focal Person from time to time on how to rapidly scout for and carry out initial identification of Invasive species.
- Offer training to the District and Regional EWRRS-PD Focal Person on the collection, preservation and transporting of samples of suspected invasive species.

All risk knowledge developed by the Technical Committee and how it must be communicated to the relevant stakeholders must be reported to the head of the authority.

C. Regional EWRRS-PD Focal Person

The Regional EWRRS-PD Focal Person is tasked with the following roles:

- Collate information from the District EWRRS-PD Focal Person and forward them to the Technical Committee.
- Conduct initial identification of a suspected invasive alien species.
- Direct the District EWRRS-PD Focal Person to initiate containment procedures if the identification confirms a possible invasive species and forward the samples to the EWRRS-PD Authority for actions to be taken on confirmation of its status.
- Communicate the final decision taken by the steering committee to the district EWRRS-PD Focal Person.

D. District EWRRS-PD Focal Person

- Participate in surveillance and monitoring activities as directed by the Technical Committee.
- Collect samples of suspected invasive alien species and forward to the Regional EWRRS-PD Focal Person
- Carry out outreach and educational programme to the community and collect feedback to the Regional EWRRS-PD Focal Person.
- Implement containment decisions as communicated by the Regional EWRRS-PD Focal Person.
- Participate in any activities being carried out by the Technical Committee in the areas under their jurisdiction.

6. LIST OF CURRENT INVASIVE SPECIES OF HIGH-RISK STATUS IN GHANA

This EWRRS-PD is developed and implemented as a means of preventing the destruction of Ghana's agricultural and environmental resources by climate-driven pests and invasive alien species. Currently several insect pests and diseases have been identified as potential species of interest in Ghana. These species have been identified to be of high risks because of one or more of the following reasons:

- They have been found to cause massive damages in environments that are similar to conditions in Ghana.
- They have been found in neighbouring countries or within the West African sub-region.
- The vectors of the diseases have been discovered in Ghana.
- There is high potential for these invasive species introductions, establishment and spread within the country and pose threat to agriculture.

A summary of the identification, biology and potential damages by these pests and diseases has been attached as appendix 1. It is recommended that the list is published in newspapers of national circulation, posted at MoFA website and other social media platforms identified by the steering committee of the EWRRS-PD where it will be readily accessible to the Regional and District EWRRS-PD Focal Persons and the public.

7. DETECTION OF AN INCURSION

For early detection of an incursion, there is the need for regular surveillance at the borders of Ghana. The surveillance can be done passively by the public and farmers, who are well informed about the issues; or actively by the EWRRS-PD Focal Person at the district levels. The active surveillance comprises structured searches or surveys that focus on high-priority target invasive species, specific geographic locations, and important pathways for introduction and dispersal. Early detection can be initiated by the report of a suspected new invasive species to the country. During the surveillance, important information such as population size, distribution and density, may also be collected. To help the identification and verification of the suspected invasive species, photographs of the insect or of the disease symptoms on the infected plant, may be very useful. For this purpose, the Horizon Scanning Tool developed by CABI may come in handy. It is advised that the surveillance is carried out at shorter intervals in Ghana as a number of invasive species with high risks level are posing threat to the country.

If any suspected invasive alien species are found, samples or photographs of either the pest or the disease symptoms are sent to the Regional EWRRS-PD Focal Person, who will then attempt to identify the species as an alien which is now entering or an alien that has already been found in the country. This may be done with help from the published list of invasive species (Appendix 1). The regional EWRRS-PD Focal Person now sends the samples and its related information to the National Focal Point (EWRRS-PD Authority) for referral to the Technical Committee for verification and advice. If the Technical Committee deems it fit, they can send samples of the suspected invasive alien species to international research institutions or accredited laboratory for

confirmation. If the Regional Focal Person identifies the incursion as high risk, then he/she can advise containment activities to prevent further spread while waiting for further instructions from the Authority. Protocols for collecting, preserving and transporting samples of suspected invasive alien species have been attached as Appendix 11.

8. PEST RISK ANALYSIS

This EWRRS-PD is contingent on the detection of certain listed invasive alien species, all identified to be of high risk (Appendix 1). However, due to the rapidly changing environment and farming practices, the risk status can change. There's therefore the need for the risk status of any suspected/identified invasive alien species to be determined. The Technical Committee must carry out the assessment and convey the results to the head of the EWRRS-PD Authority. If the risk assessment indicate that the identified pest or disease is of low risk, the decision as to not to include it further in the EWRRS-PD will be relayed to the EWRRS-PD Steering Committee for final decision to be made.

9. RAPID RESPONSE

When the suspected invasive species or a pest/disease of high risk is confirmed there shall be the need for the development of a rapid response plan. The main aim of the plan will be to eradicate the pest/disease before it spreads. The plan begins with the establishment of a rapid response team by the Steering Committee with advice from the EWRRS-PD Authority. The composition of the team will depend on the type of incursion. For example, if it is an insect pest or a disease transmitted by an insect vector the team will need an entomologist and if it's a disease, a plant pathologist will be needed. Subject matter experts such as pesticide experts and pesticide applicators may be required if pesticide application will be necessary.

Since PPRSD is mandated to use all means necessary to control such incursions, accessing the area to be treated should not pose a problem, however, if the incursion was reported on a private property, there shall be the need for the owner to be consulted prior to the application of treatments. To encourage his/her participation in the process he/she can be co-opted into the response team.

Response Plans are developed by the Rapid Response Team, and shall include instructions for pre-treatment assessment, the treatment regime, and monitoring timelines. It is important that the objectives of the response plan are clearly stated before implementation. This is necessary to enable evaluation and assessment of the actions and define the period within which the activities must be curtailed. Protocols that must be followed for the treatment of the infected/infested area are to be developed by the Technical Committee and must be followed strictly by the response team. The measures must be such that it will rapidly eradicate the incursion but must not leave environmental problems such as pollution of the environment with pesticides residues or adverse effects on non-target organisms.

There shall be the need for the impact of the implemented response plan to be assessed based on pre-determined timelines. These activities and results must be monitored, and decisions are then taken on whether the objectives were achieved (eradicating the target) or not. This should be carried out by the Technical Committee after which they advise the Steering Committee on the next line of action. If the objectives are achieved there shall be the need for the writing of a final report by the response team with input from the Technical Committee to be forwarded to the Steering Committee for archiving. If the objectives are not met, then a decision will be taken as to whether the plan needs to be modified, (based on what caused the objectives not to be realized) for re-application. However, if it becomes clear that the eradication of the pest/disease is

not possible then the Technical Committee shall advise the head of the EWRRS-PD Authority on sustainable interventions.

10. SUMMARY OF THE COMMUNICATION CHANNEL

Based on the organizational structure of this EWRRS-PD, there is the need for orderly flow of information to prevent confusion in the system. Fig. 1 illustrates the relationship of the various actors in the EWRRS-PD and the channels of communication.

10.1 Reporting detections: Detected new pest/disease situations would either be entry of a new invasive alien species into the country, resurgence of a pest that hitherto had been controlled or eradicated/eliminated or emergence of an insect which hitherto was not a pest but have attained pest status because of climate change or ecological changes resulting from human activities. Detection of any such situation would be at the farm level, through routine on-farm surveillance, trapping or interceptions at entry points. For the EWRRS-PD, such detections shall be communicated by the persons who detected the situation to the nearest link in the communication channel, which shall be either the District Agriculture Extension Agent (AEA) or PPRSD Focal Person. This information shall then be relayed to the EWRRS-PD Authority. Additionally, the Technical Committee and the knowledge generating partners would carry out horizon scanning on commodities and trade routes to establish any potential threats of pest invasion. This potential threat shall be communicated to the EWRRS-PD Authority.

10.2 Risk assessment and knowledge generation: Once a detection or potential threat is reported to the EWRRS-PD Authority, this shall be communicated to the Technical Committee, who shall initiate processes to validate the risk, carry out risk assessment of the situation and develop risk knowledge information, including awareness and response plan.

10.3 Response knowledge generation: The Technical Committee shall also compile and where necessary validate a response strategy, which shall include tools for prevention, eradication/elimination, containment or management of the risk.

10.4. Risk and response dissemination: The risk communication team shall pick up the risk knowledge information and disseminate to all relevant stakeholders using the designated communication channels, i.e., PPRSD Focal Persons at the regional and district levels and AEAs to the farmers and farmer-based organisations (FBOs).

10.5 Monitoring evaluation and learning: There shall be regular monitoring and evaluation of the system. Key lessons and information from the monitoring and evaluation shall be used to improve the system.

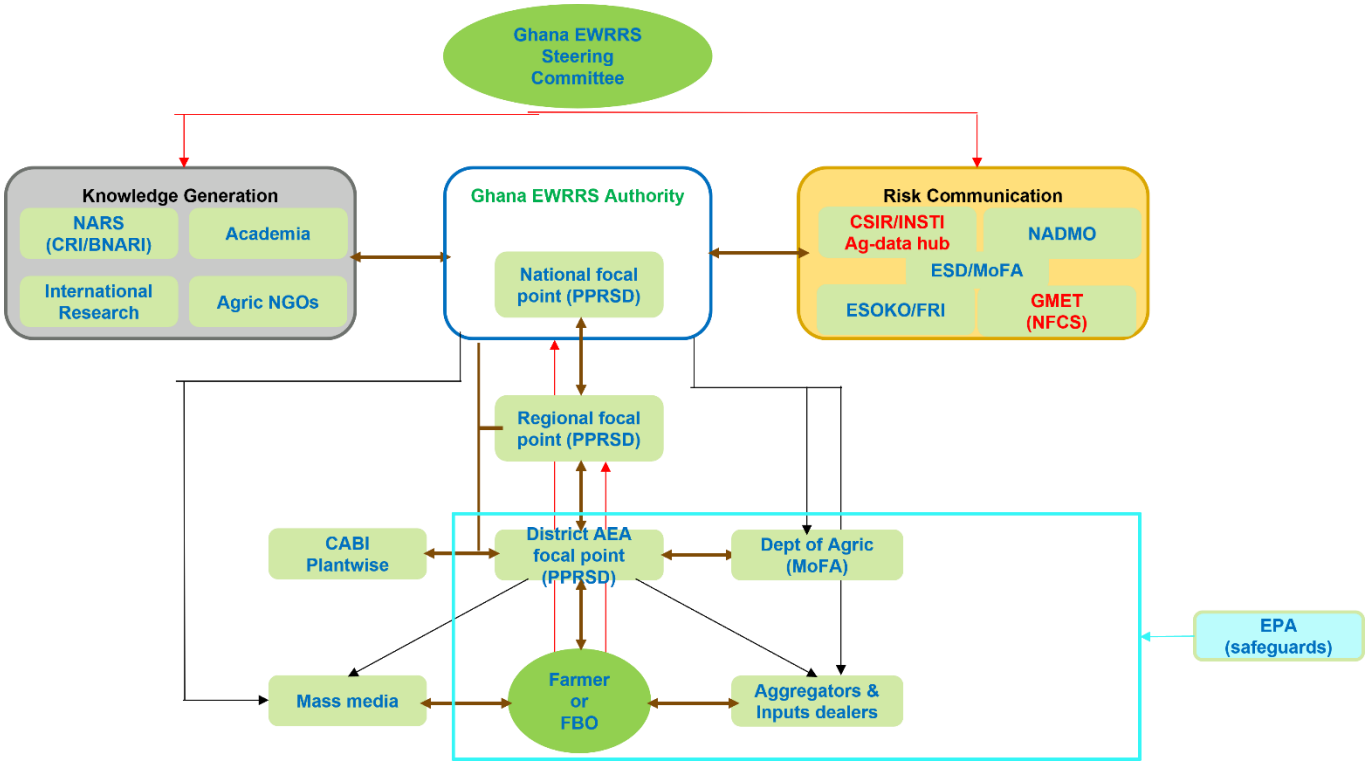

Figure 1: Framework for Ghana's Early Warning and Rapid Response System for Pests and Diseases.

APPENDICES

APPENDIX 1.

Table 1: Invasive insects with some brief information for their identification.

Pest	Possible Host Plants	Brief Description	Possible Pathways
Pea leaf miner *Liriomyza huidobrensis*	Soybean, and vegetables	Adults are 1.7 to 2.3 mm, black in colour with bright yellow spots on the thorax. Nymphs are yellow-orange in colour.	Infested leaves
Vegetable leaf miner *Liriomyza sativae*	Vegetables	Adults are 1.7 mm long with females larger than males. The face frons and third segments of antennae and scutellum are yellow and abdomen is black. Larvae are legless maggots with no separate head capsule, transparent when newly hatched but colouring up to a yellow-orange in later instars, up to 3 mm long. Both larvae and puparia have a pair of posterior spiracles terminating in three cone-like appendages.	Infested plant parts
Chilli trips/yellow tea thrips *Scirtothrips dorsalis*	Vegetables and fruit crops	Adults have yellow body with pale brown wings and bands on top of the abdomen. Larvae are pale yellow to whitish. Larvae have three-segmented maxillary palpi; head and thorax reticulate with sclerotization of head. Pupae are dark yellow with eyes and ocelli bearing red pigmentation.	Infested plant materials
Southern armyworm *Spodoptera eridania*	Vegetables and fruit crops	Adults measure 33 to 38 mm in wingspan. The forewings are gray and brown with dark brown and dark markings. Young larvae are black with yellow lateral lines, older instars are grey-brown with a dorsal row of paired black triangular spots, and subdorsal reddish lines when older; the head	Infested plant parts and flight

		capsule is yellow-brown. Larvae are characterized by a prominent yellow subspiracular line which is broken by a dark (sometimes diffuse) spot on the first abdominal segment.	
African citrus psyllid *Trioza erytreae*	Citrus (Vector of citrus greening)	Adult is light-brown in colour. Female has sharply pointed abdomen in comparison to the blunt abdomen of the male. Normally feeds by putting the head down and raising the rest of the body at 35°. Nymphs are dorso-ventrally compressed, olive-green to dark grey with marginal fringe of white, waxy filaments; largely sedentary; forms distinct colonies on the underside of young leaves. Feeding activity produces distinctive cup-shaped, open galls.	Infested leaves and fruits of the host and by wind.
Red palm weevil *Rhynchophorus ferrugineus*	Oil palm	Very large beetles with body length of 35 to 40 mm. It possesses a long slender rostrum	Infested planting materials and adult flight
Citrus blackfly *Aleurocanthus woglumi*	Citrus	Adults are small and yellowish with a cloudy spot on the apex	Infested plant materials
Peach fruit fly *Bactrocera zonata*	Mangoes, guava and peaches	Adults are 6 mm long and reddish brown with yellow thoracic markings.	Infested fruits and by flight or wind aided
Tropical fire ants *Solenopsis geminata*		Adults are 3 to 5 mm long and orange to brown in colour with brown square heads	Accidental introduction by man through infested materials
Cassava brown root scale *Stictococcus vayssierei*	Cassava, yam, banana, African oil palm, siam weed	Males are rare and the more common adult female are dark-red, circular and flattened. The eggs are laid in wax threads secreted underneath the body, and hatch into cream-white first-instar nymphs.	Infested plant parts.
Spherical mealybug *Nipaecoccus viridis*	Citrus, coffee, soursop, groundnut, jackfruit, Cajanus, coconut, cotton, soyabean etc.	Adult females are about 4 mm long and covered in mealy white wax with short projecting filaments	Infested planting materials

		arranged around the margin.	
Citrus leaf miner *Phyllocnistis citrella*	Citrus, cinnamon, golden apple	Adults are very small, whitish moth, only 2 mm in length. Wingspan is 4 mm. Markings comprise black and brown lines with an apical black spot.	Leaves of infested plants
Silverleaf whiteflies *Bemisia tabaci (MED)*	Over 600 plant species eg. Okra, pepper, melons, cabbage, potatoes, begonia, cowpea etc	Adult male slightly smaller than the female. The body and both pairs of wings are covered with a powdery, waxy secretion, white to slightly yellowish in colour.	Parts of planting materials such as barks, pods, rhizomes/suckers, true seeds
Tea shot-hole borer *Euwallacea fornicatus*	Acacia, Artocarpus, citrus, mango avocado, forest trees and shrubs	Pupae are a similar size to adults and are white. Adult females are dark brown to almost black. The males are wingless and smaller than the females.	Wood, seedlings and parts of planting materials such as barks, pods, rhizomes/suckers, true seeds, leaves
Potato aphid *Macrosiphum euphorbiae*	Potato, tomato, rose, lettuce	Large aphid, with an elongated pear-shaped body, either in a shade of yellowish-green or pinkish-red. Wingless adult females are medium to large in size. The body is often rather shiny and the eyes are distinctly reddish. The antennae are six-segmented. The legs are noticeably long.	Infested planting materials
Oleander scale *Aspidiotus nerii*	Yellow oleander, pineapple, grapevine, olive, gooseberry, acacia	Adult males are winged. The females have median and second lobes, macroduct number and marginal setae	Infested planting materials
Solanum fruit fly *Bactrocera latifrons*	Cucumber, ivy gourd, wax gourd, white-flowered gourd, guava (Psidium, pomegranate and citrus	Face with a dark spot in each antenna. Predominant colour of scutum black. Wing with an anal streak	Planting materials, contaminated soil
Florida wax scale *Ceroplastes floridensis*	*Arbutus unedo, Cedrus libani,* citrus*, Cydonia oblonga, Ficus benjamina*	The body is oval or rectangular, and it is convex in lateral view in old females, while it is nearly flat in young females. It can be found in various colors, including brown, black and white.	Infested plant materials
Vegetable weevil *Listroderes costirostris*	Vegetables such as onion, cauliflower, carrot, pepper, tomato, beetroot	Antennae with funicular segments 1 and 2 elongate, the former slightly longer than the latter. Setae short	Infested plant materials

		and dark, spiniform on small tubercles. Urogomphi are pale, darker basally with three small, associated setae. Adults are integument brown, except for antennae and tarsi which are reddish brown	
Greenhouse whitefly *Trialeurodes vaporariorum*	About 859 plant species such as aubergine, guava, common bean, celery, tea, pepper among others	They resemble soft scale insects, but have a vasiform orifice on the back through which honeydew is expelled. Adults are about 1.5 mm long, white and resemble tiny moths. The wings are pale yellow, held relatively flat when in repose and are coated with a pure white waxy bloom.	Infested plant materials
Tomato fruit fly *Neoceratitis cyanescens*	Tomato, bell pepper, African egg plant, chilli, turkey berry	Many species have wings distinctively patterned with bands or spots, which may be yellow, brown or black. The females usually have a prominent piercing ovipositor.	Fresh fruit trade, infested planting materials
Pink-spotted hawkmoth *Agrius cingulatus*	Morning glory, sweet potato	Adults have a grey-brown body with pink bands. The abdomen tapers to a point. The hindwings are grey with black bands and pink at the base	Infested planting materials,
Mexican fruit fly *Anastrepha ludens*	Citrus, mango, peach, guava, grapefruit, soursop, coffee, cashew nut, pawpaw	Adult body is mainly yellow to orange-brown, and the setae are red-brown to dark-brown with long simple wing venation curved apically. Head is yellow except ocellar tubercle brown. The antenna does not extend to the ventral facial margin.	Infested planting materials, containers and packaging materials, fruit pods, contaminated soil
West Indian fruit fly *Anastrepha obliqua*	*Spondias* spp, citrus, mango, guava		Infested planting materials, containers and packaging materials
Dictyospermum scale *Chrysomphalus dictyospermi*	Citrus, olive, palm, bamboo, avocado, guava, ginger etc.	scale cover of the adult female is thin, greyish or reddish-brown, often with a coppery tinge. The adult male has a pair of wings with simplified venation, well-developed legs and antennae and long genitalia, but lacks	Plant parts such as barks, trunks, branches and seedlings/ micro propagated plants

		mouthparts or any distinct 'neck	
Cotton tipworm *Crocidosema plebejana*	Okra, cotton, eucalyptus, lima bean, wheat, grapevine	Moths are small slightly larger in the females. The male has forewing with a short costal fold at the base which is absent in the female.	Infested seeds, contaminated soils, flowers, fruits, leaves.
Cucumber moth *Diaphania indica*	Watermelon, cucumber, melon, pumpkin and snake gourd	The wings are translucent white with a wide brown border. The females wiggle brush (hair), to send out a chemical to attract the males	Infested planting materials
Rice armyworm *Mythimna unipuncta*	Barley, millet, oats, rice, rye and wheat, maize, potato and grasses	Females are larger than males. Adults Moths vary in colour from pale-beige to a dark reddish-brown, with a distinctive single white spot on each forewing.	Parts of planting materials
Citrus flower moth *Prays citri*	Citrus lemon, grapefruit	Adults have light grey forewings with dark grey/black spots and greyish brown hindwings and body.	Parts of plants, clothing, soil etc
Greater sugarcane borer *Sesamia cretica*	Sugarcane, corn, sorghum, millet etc	The forewings are pale whitish brown, variously marked with darker brown, and the hindwings are white. Male antennae are biciliate. The males smaller than females	Dried maize stem (pupae), seed trade
Vinegar fly *Zaprionus tuberculatus*	Pineapple, banana, and melon	Four white horizontal stripes across its head and thorax. Males bear hairs on their forelegs. Both male and female flies have a protruding bristle from the forefemur	Fruits of host plant
Greedy scale *Hemiberlesia rapax*	Acacia koa, apple, avocado	The adult female insect lacks wings, legs, or eyes, and the dead ones are dark brown and dried rather than plump.	Infested plant material
Gray bird grasshopper *Schistocerca nitens*	corn, wheat, cotton, oats	The grasshopper is known for its cryptic coloration, which is mostly brown, and grey spotted or patched.	Infested plant material and wind dispersal
Banana moth *Opogona sacchari*	Banana, sugarcane, and pineapple	Adults are almost uniformly clear, yellowish-brown in colour. The wingspan is 18 to 26 mm. The forewings are brown suffused with a golden glow and with two	Natural dispersion by flight/wind and import and trade of plants for planting of host plants, such as Dracaena

		small black dots and may display dark brown bands.	
Citrus orthezia *Orthezia praelonga*	citrus, cactus, Ficus	Adult females and immatures have well-developed, prominent, dark legs and antennae. The body is covered in white waxy plates that are quite ornate.	Infested plant material
False oleander scale *Pseudaulacaspis cockerelli*	Citrus crops and coconut palm	The female matures into an oval, bright yellow, feeding and egg-laying body hidden under a white, pear-shaped armour, while males are protected by armour.	Infested plant material
Bronze bug *Thaumastocoris peregrinus*	Eucalyptus spp. Corymbia spp.	It is a small (2-3mm) sap-feeding insect. The adults are flat-bodied and light brown in colour with darker shaded areas.	Infested plant material and dispersal by air travel
Boll weevil *Anthonomus grandis*	Cotton	The adult weevils are small (ca. 12 mm) and have long slender snouts and spurs on the upper joint of the front legs. Their colours vary from dark, brownish red to brown or near black. Females oviposit in squares and bolls.	Transport of infested cotton seeds and fruit
Carambola fruit fly *Bactrocera carambolae*	Mango, guava, and orange	Characterized by a predominantly black thorax, while featuring abdominal segments with brown lateral posterior markings and a medial longitudinal black band over all three tergum. The head of this species is reddish brown with one pair of ovals, black compound eyes, and sucking/piercing mouthparts. This species can reach a length of 6 to 8 mm (0.6 cm to 0.8 cm).	Movement in trade with infested fruit and infested plant material
Queensland fruit fly *Bactrocera tryoni*	Apple, cashew and avocado	Adults are red brown in colour. Males have a surstylus that is short and have a needle-shaped aculeus. Females have a longer proboscis and aculeus, which is curved downwards. The abdominal terga are	Transport of infested fruit and movement within infested area.

		generally red brown with a medial.	
Painted bug *Bagrada hilaris*	broccoli, cauliflower, and cabbage	The adult body is shield-shaped, ranging in size from 5–7 mm long and 3–4 mm wide, with females slightly larger than males. The coloration of the adult is black with red and yellow markings.	Natural dispersal and movement within infested area.
Palm aphid *Cerataphis lataniae*	Palms and orchids	Shiny-brown or orange-brown with a flat white fringe of wax, Adults are small, oval, and flattened, measuring 2-3 mm in length. Nymphs: Similar to adult C. lataniae, but smaller in size.	Infested plant material
Spotted borer *Chilo sacchariphagus*	Rice, sugarcane, and sorghum	The moth has a wingspan of 12-18 mm, with dull light-brown forewings outlined in whitish-beige.	Import and trade of plants for planting of host plants
Eggplant mealybug *Coccidohystrix insolita*	Egg plant and tomato	Adult females are oval and light to dark grey in colour. Immature stages do not secrete a thick layer of mealy wax, and the body is shiny yellow-green with submedian grey spots on the 2 abdominal and 1 thoracic segment.	Infested plant material
San José scale *Diaspidiotus perniciosus*	Peach, pear and apple	The female insect is almost circular, slightly convex, and light to dark grey, with a diameter of about 1.5-2.2 mm.	Infested plants
Banana skipper *Erionota torus*	Banana and plantain	The wingspan of the butterfly is 70–77 mm, and there are multiple generations per year. The larvae of Erionota torus feed on the leaves of Musa species, especially Musa textilis.	Infested plant material
Coconut mealy bug *Nipaecoccus nipae*	Soursop, breadfruit, pigeon pea, pawpaw, citrus, coconut, African oil palm	The adult female has 5 to 8 waxy filaments on its dorsum, similar in shape and size to those on the lateral areas of its body. Adult female is flat and oval. They are salmon-pink to dark-red in colour with distinctive dorsal and marginal white or yellow	Infested soursop fruits and leaves

		wax cones which create a satellite appearance.	
Potato tuber moth *Phthorimaea operculella*	Tomato, tobacco, and potato	Adults are small elongate Gelechiid moths, measuring about 1 cm in length when at rest, coloured pale brown with darker marbling. Wingspan is 15-17 mm	Infested plant material
Obscure mealybug / tuber mealybug *Pseudococcus viburni*	Vineyard, Apple and pear	The bodies of nymphal and adult female obscure mealybugs are rectangular, with rounded anterior and posterior ends. Adult females range from 1-5mm in length	Natural dispersion, breeding and propagation, cut flower trade, nursery waste disposal
Two-spotted leafhopper *Sophonia orientalis*	Grapevine and coconut	It is pale yellow with a brown stripe running down its back, and two prominent spots at the end of the wings	Wind aided
Xyleborus similis	Avocado and Cocoa	The body length of the female ranges from 2.2 to 2.7 mm. The frons is convex, and the entire surface is minutely reticulate with faint, shallow punctures. The pronotum sides are nearly straight, whereas the anterior margin is broadly rounded, and without serrations. The elytral apex is narrowly rounded, and the elytral declivity is sloping and convex. There is a large, distinct tubercle located on the lower third in interspace 1. Elytral interspace 7 is acutely elevated and very weakly crenulate.	Natural dispersion of females, trading of infested plant parts such as bark, shoots, branches, woods.
Brown twig beetle *Xylosandrus morigerus*	Coffee	Body length of the female ranges from 1.5 to 2.0 mm. Body light to dark brown. Antennae and legs are yellowish brown. Antennea with 5 funicular segments	Natural dispersion of females, trading of infested plant parts such as bark, shoots, branches, roots, micro propagated plants, seedlings, woods.
Cocoa pod borer *Conopomorpha cramerella*	Cola, cocoa, lichi, rambutan,	It is mosquito-sized moth about 5-7 mm long and brown with bright yellow patches at the tips of the forewings	Infested plant material

Argentine ant *Linepithema humile*	Stored food and other products	The workers of *L. humile* are small (2-3 mm long), brown and monomorphic. Their petiole is small and composed of a single segment. Males are also small (2.8-3 mm long), winged, dark brown, with a very robust and elliptical thorax, broader than the head. Queens are larger (4.5-5 mm long), dark brown with a large thorax, as broad as the head.	Accidental introduction through humans
Red locust *Nomadacris septemfasciata*	Citrus, coffee, cassava, tobacco, rice, millet, maize, sugarcane, sorghum.	Females are 55-85 mm, males 50-70 mm. Solitarious adults are larger on average than gregarious ones. The former are largely (reddish) brown and grey. Their tegmina carry oblique spots or fasciae (usually seven) and their wings are clear and pale red to purplish at the base. Gregarious adults are more reddish in general colour especially the younger ones	Infested planting material
Red gum lerp psyllid *Glycaspis brimblecombei*		Adults are approximately 4-5 mm in length from the head to the wing tips. The colour of the adult is yellow or light green with contrasting dark eyes, and with occasional dark-brown markings.	Natural dispersion of adults, land transportation of vectors, trading of infested plant material such as leaves and stems.
Leucaena psyllid *Heteropsylla cubana*	Leucaena, mimosa, rain tree	Adults slender, 1.5-2 mm long, usually yellowish-green but some may be of varying shades of brown; wings become transparent with age	Transportation of infested plant material, by flight and wind.
Onion fly *Delia antiqua*	Onion and garlic	The flies are slender, greyish and large-winged. The maggots are small, white and about 8 mm in length. The females lay elongate, white eggs near the base of the plant in cracks in the soil,	Infested plant materials
Diaprepes root weevil, citrus root weevil and sugarcane rootstock borer weevil	Maize, Cotton, Sugarcane, Tobacco	Colorful weevil (10–19 mm) long, with numerous forms or morphs, ranging from	Infested plant material, Nursery potting medium

Diaprepes abbreviates		grey to yellow to orange and black	
West Indian sweetpotato weevil *Euscepes postfasciatus*	Sweet potato	The adult weevil is reddish brown to near black, with a compact body covered with short bristles, which are arranged in parallel rows on the abdomen. The head is small and protrudes little from the thorax except for a prominent, downward-curving snout	Infested plant material
Carnation tortrix *Cacoecimorpha pronubana*	Citrus, vegetables	Pupa Initially brown, becoming almost black. Adult Wingspan 15-17 mm in males, 18-24 mm in females, forewings rectangular, yellowish-brown to purplish-brown in colour with two (in males, one in females) narrow, darker, obliquely transverse bands. Hindwings orange with dark-brown edges.	Plant trade of infested leaves, flowers, calyx
Blue gum psyllid *Ctenarytaina eucalypti*	Eucalypts	The adult is green to tan, but with dark-brown to black head. Metacoxal meracanthi not elongated and the apical cell of the forewing (medial cell) is short, usually shorter than the cubital vein	Trading of infested plant materials such as leaves, stem, branches
Eucalyptus snout beetle, the eucalyptus weevil or the gum tree weevil *Gonipterus scutellatus*	*Eucalyptus* trees	The female is 7.5-9.4 mm and the male is 5.7-8.9 mm). It is grey-brown, with a light transverse band on the elytra. The rostrum is 15 mm long; the prothorax is 2.2 mm long; and the elytra are 6.2 mm long and 4.6 mm wide.	Transportation of soil, gravels, trading of infested plant parts such as calyx, flowers, barks, leaves, stem, growing medium.
Cactus mealybug *Hypogeococcus pungens*	Copper leaf, devils horsewhip, calico plant, globe amaranth.	Female adults are about 3mm long. Female adults and nymphs are oval and covered in a white waxy coating giving them a mealy appearance. Males are small aphid-like winged insects	Plant trade of leaves, root, seedlings, stem, flowers, wind
Parlatoria Date Scale *Parlatoria blanchardi*	Dates and palms	The adult female is an elongated oval shape, and is whitish, with a pale brown raised area with a darker brown or blackish central	Transportation of infested plants and by wind

		area. Underneath the scale, the insect is nearly circular, pink at first, changing to yellowish-brown when mature. Males can be winged or wingless, but females never have wings.	
Peach scale *Parthenolecanium persicae*	Raspberry, blackberry, acacia, roses, citrus, walnut, mango, avocado	Adult females are highly variable, not strongly convex elongate oval with medial longitudinal ridges. Young adult females are usually yellowish with brown markings or mottling. Antennae 8-9 segmented.	Wind dispersal, Transporting cuttings, trading of pant parts
Eucalyptus longhorned borer *Phoracantha recurva*	Several species of eucalyptus, mahogany	Adult head, pronotum and ventrites of the adult are reddish-brown to dark reddish-brown. The antennae and legs are yellowish-brown to reddish-brown. The antennae are 1.6 times as long as the body in the males and slightly longer than the body in the female. The male is 15-28.8 mm long and the female is 19.5-29.2 mm long	International trade or regional trade, the eggs, larvae, pupae and adults can be transported in logs, solid wood packing material (SWPM) or saw timber.
Fruit-tree pinhole borer *Xyleborinus saxesenii*	*Abies alba* (silver fir), *Fagus sylvatica (*common beech)	Males are smaller than the females, have reduced eyes, and lack wings. Length 2.0-2.4 mm, 2.6-3.0 times longer than wide.	Infested plant materials
Russian wheat aphid *Diuraphis noxia*	Wheat (*Triticum* sp.), barley (*Hordeum vulgare*), oats (*Avena sativa*)	Yellow green to grey-green spindle-shaped aphid, 1.4-2.6 mm long as an adult. Integument covered with a waxy white exudate.	Infested plant material, wind dispersal
Mexican bean beetle *Epilachna varivestis*	Common bean (*Phaseolus vulgaris L.*), Lima bean (*Phaseolus lunatus* L). Soybean (*Glycine max*)	The adult is oval in outline, and about 6 to 7mm in length. The newly emerged adult is of a straw or cream-yellow colour. The adults darken with age until they become orange-brown with a bronze tinge. The males are slightly smaller than the females.	Infested plant material
Bactrocera kandiensis	*Mangifera indica* (mango), *Garcinia* spp., *Anacardium occidentale* (cashew nut)		

Potato flea beetle *Epitrix cucumeris*	Potato (*Solanum tuberosum*), Tomato (Solanum lycopersicum), Aubergine (*Solanum melongena*)	The adults are small black beetles, 1.6-2.0 mm long, with rows of punctures along the elytra arranged into striae and one row of white setae between elytral striae. The hind femurs are enlarged, adapted to jumping.	Short distance: by flight, jumping and walking. Long distance spread is through the commercial transport of potato tubers (seed or ware potatoes), when associated with soil and plant debris
Banded fruit weevil *Phlyctinus callosus*	Grapevine (*Vitis vinifera*), Nectarines (*Prunus persica*), Carrots (*Daucus carota,*), Parsnips (*Pastinaca sativa*), Apple (*Malus domestica*)	Adults are flightless weevils (body length: 4.8-6.1 mm), greyish brown, with a bulbous abdomen which has the characteristic pale-white V-stripe that is prominent at the posterior margin.	Infested plant parts (associated with fruits in trade)
Alfalfa seed chalcid *Bruchophagus roddi*	Medicago plants (Alfalfa/lucerne)	The adult alfalfa seed chalcid is a minute, jet-black wasp. Only some parts of the legs (on the tibia and tarsus) are yellow brown. The male is 1.2-1.7mm and the female is 1.3-1.8 mm long. The thorax protrudes and the abdomen is egg-shaped with a plain ventral part	Adult flight (in restricted areas) and infested seeds.
South African carnation tortrix *Epichoristodes acerbella*	*Dianthus caryophyllus, Chrysanthemum morifolium*	Larva is 1.75 cm in length, body green with a darker line on the dorsal surface and two lateral yellow lines, head dark brown; moves very quickly. Adult is 14-24 mm wingspan; light-ochre forewings, often with a darker band towards the distal edge; greyish-white hindwings	Spreads by adult flight and by infested plant parts
Olive fruit fly *Bactrocera oleae*	Olives and Tomato	Adult olive fruit flies are relatively small, measuring around 3 to 4.5mm in length. Typically have a mottled appearance, with shades of yellow, brown, and black.	Adult flight and the transport of infected fruit.
Cuban laurel thrips *Gynaikothrips ficorum*	*Ficus microcarpa* (Indian laurel tree), *Ficus retusa* (retuse fig)	Female body is about 2.5 to 2.8 mm long and is mainly black in colour. Male is smaller than the female	Infested plant material

		and typically yellow in colour	
Cabbage stem flea beetle *Psylliodes chrysocephala*	*Brassica oleracea* (cabbages, cauliflowers), *Brassicaceae* (cruciferous crops)	The adults are around 3-5 mm long, black, usually with a blue-green metallic sheen but variations in size and coloration occur.	By flight, infested plants, plant material or contaminated soil.
Pelargonium butterfly *Cacyreus marshalli*	*Pelargonium* (pelargoniums), *Geranium* (cranesbill)	Female adults have a wingspan of 18-27mm while male adults have a wingspan of 15-23 mm. It has a bronze colouring on its upper surface with white spots on the fringe.	Infested plant material
Mulberry whitefly *Pealius mori*	Spurges *(Euphorbia)*, White mulberry (*Morus alba* (mora))	small with a distinctive flattened and oval-shaped body, measuring about 1 to 2mm in length. The adult females are covered in a waxy substance, giving them a white or light grey appearance.	Infested plant material
Bougainvillea mealybug *Phenacoccus peruvianus*	*Bougainvillea glabra, Capsicum frutescens* (chilli), *Solanum lycopersicum* (tomato)	Adult females are elongate oval, greyish with a green tinge, covered in a thin layer of mealy white wax, and attain a length of 3.0 mm. They can range in colour from light yellow to pink or reddish-brown.	Infested plants or plant materials.
Cypress aphid *Cinara cupressi*	*Juniperus scopulorum* (Rocky Mountain juniper), *Cupressus lusitanica* (Mexican cypress), *Juniperus procera* (African pencil cedar)	brownish-grey aphids covered in long, slender hairs, including hairs on the conical siphuncle.	By flight and through infested plant materials
Pine woolly aphid *Pineus pini*	*Pinus pinea* (stone pine), *Pinus caribaea* (Caribbean pine)	Adults are similar to the immature instars, being ovoid with dorsal segmentally arranged sclerotized plates ornamented with wax glands, and short legs and antennae concealed beneath the body. However, the adult females each possess an ovipositor, which is lacking in the immature stages.	Infested plant material
Potato tuber moth *Tecia solanivora*	Potato (*Solanum tuberosum*)	The female is larger than the male, measuring approximately 13 x 3.4 mm, whereas the male measures 9.7 x 2.9 mm. The	Infested potatoes or soil

		female is bright brown. The male is dark brown.	

Table 2. A list of invasive disease threatening the agricultural resources of Ghana

Common name	Pathogen	Recognition	Pathways
Phytophthora stem rot of cowpea	Phytophthora vignae	Plants have white bleached appearance	Plant parts and growing medium.
Pineapple heart rot disease	Phytophthora cinnamomi	Chlorosis, wilting and die-back	Symptomless plants. Currently in Ivory coast
Phytophthora foot rot of pigeon pea	Phytophthora drechsleri	Wilting of plants	Infected roots, growing medium and run-off water
Foot rot of tomato	Phytophthora cryptogea	Discolouration and girdling of stem and plant dislodging	Infected roots, growing medium and run-off water
Maize or sugarcane downy mildew	Peronosclerospora sacchari	Presence of yellow to white stripes that covers the entire length of the leaf	Symptomatic plants
Leek rust of onion and garlic	Puccinia allii	Bright orange to brown circular to elongated pustules	Seed-borne
Frosty pod rot of cocoa	Moniliophthora roreri	Presence of thick layer of mycelium on cocoa pods	Infected pods, winds and water
Cocoa witches broom	Moniliophthora perniciosa	Small, pink mushrooms on pods and broom-like structures on stem	Seed-borne
Fruit rots of mango	Neofusicoccum mangiferae	Tearstained patterns and localized lesions that appear as discrete superficial spots on fruits	Airborne or windborne.
Onion smudge	Colletotrichum circinans	Necrotic lesions with dark spots concentric rings	Seed borne
Rust of cereals	Puccinia agrophila	Symptoms not visible to naked eye but usually under light microscope	Leaves of Poaceae (Present in Ivory Coast, Nigeria)
Phomopsis leaf blight, fruit rot, brown spot,	Phomopsis vexans	Poor seed germination, damping -off of seedlings, leaf and stem lesions to fruit rots	Seed borne
Dwarf mosaic of maize	Maize dwarf mosaic virus	Mosaic pattern or blotches on leaves, short internodes and reduced ear formation	Aphids, seeds and contact (Present Burkina Faso; Ivory Coast)

Mild mottle virus	Pepper mild mottle virus	Chlorosis of leaves, Stunting and lumpy fruiting structures	Humans
Mottled viral disease of egg plant	Eggplant mottled dwarf virus	Mottling, dwarfing and poor fruit set	Leafhoppers, inoculation sap and seeds
Curcurbit yellow stunting disease	Cucurbit yellow stunting disorder virus	Chlorotic yellow spotting, stunting and leaves roll upwards and become brittle	Whitefly
Cucumber greem mottle viral disease	Cucumber green mottle mosaic virus	Mosaic mottling of leaves, leaf distortion, vein clearing, vein banding internal discoloration of fruits and rotting	Seed-borne
Maize stripe disease	Maize stripe virus	Chlorotic stripes of various width along the leaves, the apex is typically curved, leaves become eventually chlorotic, with thick the reappearance of thick green discontinuous stripes	Insect vectors
Maize Chlorotic mottle Disease	Maize chlorotic mottle virus	Mild chlorotic mottling to severe yellowing, necrosis, stunted growth with short malformed, pale green stripes, paritially filled ears.	Insect vector (maize thrips)
Cocoa yellow mosaic viral disease	Cacao yellow mosaic virus	Mosaic and chlorosis on leaves and mottling on pods of cacao	Mealybug
Cassava brown streak viral disease	Cassava brown streak viruses	Leaf chlorosis, brown streaks on stems and dry hard rot in roots	Whitefly *Bemisia tabaci*
Banana Bunchy Top	Banana bunchy top virus	Dark green on light green, dot-dash flecks and stripes forming characteristics hook shape at the midrib, stunted growth	Benin, Togo Insect vector (aphids**)**
Tomato spotted wilt viral disease	Tomato spotted wilt orthotospovirus	Stunting, wilting, bronzing of the upper sides of young leaves, which later develop distinct, necrotic spot, leaves may be cupped downward, some tip dieback may occur.	Burkina Faso; Ivory Coast. (thrips)

Maize lethal necrosis viral disease	Maize lethal necrosis virus	Mottling, chlorosisLeaf necrosis, premature aging, small cobs and plant death, malformed or no ear rotting cobs	Insect vector (thrips, rootworms and leaf beetles)
Rice bacterial blight disease	Xanthomonas oryzae pv. oryzae	Wilting and yellowing of leaves, wilting of seedlings. Leaves appears as small-soaked spots, light green areas or both.	Present in Burkina Faso and Togo. Through wind, a splash of rain or irrigated water
Clavibacter michiganensis	Clavibacter michiganensis	Stunting, Wilting and canker on the stem, whereas blister-like spots develop in locally infected leaves, vascular discoloration and lesions on the fruits	Togo Seedborne
Bacterial leaf streak of rice	Xanthomonas oryzae pv. oryzicola	causes narrow, dark-greenish, water-soaked, interveinal streaks of various lengths, initially restricted to the leaf blades. The lesions enlarge, turn yellowish-orange to brown (depending on cultivar), and eventually coalesce.	Burkina Faso; Ivory Coast. By wind or rain and by cultivation when foliage is wet.
Bacterial wilt of tomato	Ralstonia solanacearum	Wilting and yellowing of leaves and stunted plants	present in Burkina Soil-borne disease Through waterways
Banana wilt disease	Xanthomonas campestris pv. musacearum	loss of turgor and wilting in the spear (youngest emerging leaf) or one or more of the young leaves, sometimes preceded by yellowing and distortion, especially in young plants. Older leaves develop a pronounced yellowing, followed by wilting, necrosis and breakage of leaf bases owing to loss of turgor.	Soil-borne mostly through diseased plant materials
African greening	Candidatus Liberibacter africanus	New growth may display shoots that are yellow or pale green with small leaves growing upright and gradually become leathery. Leaf veins on these shoots become a prominent yellowish colour and leaves of	By a psyllid vector

		infected branches are frequently smaller.	
Bacterial blight of endive	Pseudomonas cichori	Symptoms typically begin with water-soaked lesions near the leaf margin, midvein, or randomly distributed as spots. These circular lesions gradually enlarge, transforming into dark brown or black areas	Seedborne spread; natural dispersion; vector transmission (*Liriomyza trifolii*); Infested plant material
Citrus greening	Candidatus Liberibacter	Early symptoms include blotchy mottling, yellow shoots, and hardened leaves. Progression reveals secondary symptoms like zinc or manganese deficiency, corky veins, upright small leaves, twig dieback, and a sparse canopy. With disease progression, the fruits are often small, lopsided, can have a sour or bitter taste and are poorly coloured (hence the origin of the name greening)	Insect vectors (citrus psylids), plant grafting and movement of infected plant materials.
Guava root-knot nematode disease	Meloidogyne enterolobii-	Stunted growth, wilting, leaf yellowing and deformation of plant organs, knotting on roots. Water- and nutrient- stress.	Present in Burkina Faso, Ivory Coast and Togo. Primarily through the movement of infected seed or plant parts for propagation. Wind, water, insects, birds tools and equipment.

APPENDIX 2.

Sampling and shipment of insects for identification

Selection of specimens

Generally, specimens of adult insects are required for identification purposes, but there are exceptions, which are indicated in the section on preservation. Specimens need to be in good condition with all appendages (wings, legs, and antennae) intact, as identification of broken or incomplete specimens is difficult or impossible. Specimens could be killed by leaving them in a freezer for half an hour or longer depending on their size. Many smaller insects can be directly killed and preserved in ethyl alcohol. They should be preserved and sent with

other stages (eggs, larvae, nymphs, pupae, and pupal cases), as the immature stages of many species are still not well known. In the case of whiteflies, pupal stages are essential. A sample that is sent for identification should consist of about five specimens to allow a sure identification. Some specimens should be kept for reference and possible future use as samples.

Preservation

All specimens should be handled with great care to avoid distortion, breakage and loss of antennae, legs, wings, heads, scales, setae or other parts that may be essential for identification. Specimens should be as clean as possible. The preferred killing agent for adult insects is the vapour of ethyl acetate as this leaves the specimen relaxed. If adult insects and other arthropods are to be preserved in 70% or 80% ethyl alcohol (not formalin) they can be killed in this fluid also. Many immature insects, because of their softer structure, are normally killed and preserved in alcohol. However, larvae and pupae should be killed in boiling water (for one minute). Adult stages of small insects like aphids, whiteflies, thrips, scale insects, mealybugs, ants and mites and larvae and pupae should be preserved in ethyl alcohol (70-80%) or in other fluid preservatives (but not formalin) in glass or plastic tubes. These tubes should not be too large as this makes searching for very small specimens, like mites, very difficult. The tubes should be completely filled with fluid, to exclude air bubbles (moving air bubbles can do a lot of damage during transit), and should be securely sealed, preferably with screw-on caps, but not with corks as these may soon deteriorate. Adult stages of larger insects may be preserved on dry pins, preferably stainless-steel pins that do not rust and damage the specimen. Do not stack specimens on the same pin with one data label because the weight may become too heavy for the pin and you may include several species under one label. Do not put Lepidoptera and other insects in the same box because the scales of the wings from the Lepidoptera will stick to small insects and hide their taxonomic characters.

It is also possible to preserve larger adult insects dry in paper envelopes or packets, or loosely packed between layers of cellulose wadding or tissue paper (but not cotton wool) in boxes, but these methods should only be used when there is no alternative. It is essential to dry specimens thoroughly before storage to prevent the growth of moulds and the development of mites and other organisms that will rapidly destroy specimens.

Labelling

All specimens submitted for identification should be clearly labelled with basic information on:

- country;
- locality (including the nearest place likely to be recorded on maps.);
- altitude (if appropriate);
- English and preferably scientific names of host plant(s);
- other relevant information e.g. feeding on leaf or on fruit;
- result of problem – e.g. plant dying, fruit or tuber inedible, leaves fall off or lose colour;
- date collected; name of collector and organisation; reference number.
-

Labels should not be too large, and should be neatly written with a pencil or permanent ink (but not with a ballpoint pen whose ink will dissolve).

Packing

Specimens must be packed carefully before dispatch because inadequate packing may result in severe damage or total loss.

Pinned specimens should be sent in strong but light cardboard boxes with secure bases of cork or Plastazote into which the pins are deeply and firmly inserted. Expanded polystyrene should not be used as a base because it has insufficient grip to hold pins in place. Large specimens should be secured with several long pins to prevent any movement of the specimen or their labels and placed in a box for shipment. Tubes containing specimens in alcohol or other fluids should be checked for leaks, and if necessary sealed with molten candle wax, then be carefully packed in cellulose wadding, tissue paper, cotton wool, newspaper or other packing material and placed in a box for shipment. Boxes containing pinned specimens, slides or tubes should be sealed with tape and packed in strong cardboard cartons with a thick layer (at least 5cm) of polystyrene chips, crumpled paper, or other resilient packing material surrounding them on all sides to absorb any shocks or vibrations that might otherwise cause damage in transit.

Posting

The sender needs to enquire about such or similar restrictions in the country of destination prior to shipment and then prepare the specimens so that they conform to both the national and international safety requirements. Specimens should be sent by the fastest and most reliable method. Specimens are to be accompanied by a phytosanitary certificate and an import permit if required. A covering letter stating the sender's name and address and what information is required must be included in the package and sent with the specimen. The box needs to be wrapped in brown paper. The package needs to show the sender's address and the correct address of the specialist who identifies the sample. The package should also state the following:

'Dead Insects Preserved for Scientific Use, of No Commercial Value' and the wording 'Fragile' or 'Handle with Care'.

NB. ENSURE THAT YOU HAVE THE CORRECT IMPORT PERMITS AND CONTACTS IF YOU ARE SENDING THE SAMPLES OVERSEAS

ANNEX 3.
Sampling and shipment of disease specimens for identification

Care should be taken when packing disease specimens. When collecting, the specimen should not be kept in the heat, especially in direct sunlight. Plastic bags should be AVOIDED at all costs, as they cause the specimen to "sweat" and this encourages the growth of other organisms that may hide the real disease-causing organism. Try not to collect disease specimens that are wet. Ensure that, with each specimen, some diseased and some healthy tissue is included; the two should be packed separately. If you know whether the disease is fungal, bacterial or viral, the following instructions can be used:

Fungal

Specimens can be collected and wrapped in newspaper. The sheets of newspaper can then be put into a paper envelope and placed in a cardboard box with polystyrene or other packaging material that will protect the specimen from damage.

Bacterial

Bacterial disease specimens often deteriorate rapidly, leaving the plant bacteriologist receiving the sample with an oozing mess. If the specimen dries out, the bacteria will die and it will not be possible to identify the disease. Ideally, specimens should reach the plant bacteriologist within 12 – 24 hours of collection to be of use.

Slope cultures in miniature vials of fungal and bacterial pathogens may be prepared and sent instead of fresh samples. This method has been shown to be very successful.

Viral

Filter papers or thick tissue paper should be soaked in 50% glycerol so they are totally wet but not dripping. The specimens should be placed between the papers and the whole sample placed in a plastic bag.

Nematodes

Specimens collected from plants suspected of attack by nematodes must include both roots and soil, packed separately in plastic bags. Nematodes can also be extracted and placed in 25% glycerol or 5% formaldehyde in miniature vials and sent for identification. Alternatively, nematode extracts may be embedded in glycerine and the cover slip sealed with nail polish on a slide and sent.

Unknown
Follow fungal specimen instructions.
Collection details to include with specimen:

- Common name and preferably scientific name of host plant(s);
- Affected part of plant;
- Country, state, locality;
- Map references and altitude (if possible);
- Collection date (very important if isolations from the tissue are to be attempted);
- Collector's name;
- Tentative identification by symptoms and morphology of organisms;
- Disease severity, e.g. number of plants affected (is it one plant on the edge of a field or is the whole area affected; this will help to identify the importance of the problem);
- Reference number.

Posting

Specimens should be sent by the fastest and most reliable way. A covering letter stating the sender's name and address and what information is required must be included in the package and sent with the specimen. Pack the container with brown paper. A declaration form obtainable at Post Offices must be completed and stuck on the parcel containing the samples.

Samples should be sent to their destination as soon as possible. Label the box clearly and state:

"Perishable biological material. Keep material cool but DO NOT refrigerate - no commercial value;", "Fragile" or "Handle with care".

ENSURE THAT YOU HAVE THE CORRECT IMPORT PERMITS AND CONTACTS IF YOU ARE SENDING THE SAMPLES OVERSEAS

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