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CAMEROON BIOSECURITY PROJECT

Development and Institution of a National Monitoring and Control System (Framework) for Living Modified Organisms (LMOs) and Invasive Alien Species (IAS)

TRAINING MANUAL IN INSPECTION SYSTEMS AND METHODS INCLUDING TREATMENTS

This training manual has been produced with the support of UNEP/GEF and the Government of Cameroon via the Ministry of Environment, Protection of Nature and Sustainable Development.

Under the Supervision of:

Project Component Three Taskforce (MINESUP)

&

The Biosecurity Project Coordination Unit (MINEPDED)

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LIST OF ACRONYMS AND ABBREVIATIONS

ABBREVIATION/ ACRONYM	FULL NAME
AC	Animals Committee
AEWA	Agreement on the Conservation of African-Eurasian Migratory Water Birds
AIA	Advance Informed Agreement
ALPP	Areas of Low Pest Prevalence
ANOR	Agency for Standards and Quality
AP	Adventitious Presence
APHIS	Animal and Plant Health Inspection Service
BNF	Biological Nitrogen Fixation
BTS	Border and Transportation Security
BWM	Ballast Water Management
BWMS	Ballast Water Management System
CAC	Codex Alimentarius Commission
CBD	Convention on Biological Diversity
CBP	Cameroon Biosecurity Project
CITES	The Convention on International Trade in Endangered Species (of Wild Flora and Fauna)
CNDT	National Committee for Technology Development
COP	Conference of the Parties
CPB	Cartagena Protocol on Biosafety
CBPA	Customs and Border Protection Agency
CMS	Convention on Migratory Species
CPM	Commission on Phytosanitary Measures
CSOs	Civil Society Organizations
DNA	Deoxyribonucleic Acid
ELISA	Enzyme-Linked Immunosorbent Assay
EPPO	European and Mediterranean Plant Protection Organization
EFSA	European Food Safety Authority
ERA	Environmental Risk Assessment
ETO	Ethylene dioxide
EU	European Union
FAO	Food and Agriculture Organization of the United Nations

FMD	Foot and Mouth Disease
GATT	General Agreement on Tariffs and Trade
GEF	Global Environment Facility
GIASI	Global Invasive Alien Species Information
GISD	Global Invasive Species Database
GISP	Global Invasive Species Programme
GM	Genetically Modified
GMOs	Genetically Modified Organisms
GMP	Good Manufacturing Practices
HIV	Human Immunodeficiency Virus
HIV/AIDS	Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome
HPR-	Highly Polymorphic Region-
HPR0	Non-deleted Polymorphic Region
IAPSC	Inter-African Phytosanitary Council
IAS	Invasive Alien Species
ICAO	International Civil Aviation Organization
IHRs	International Health Regulations
IMO	International Maritime Organization
IMPM	Institute of Medical Research and Medicinal Plant Studies
IPPC	International Plant Protection Convention
IPFSAPH	International Portal on Food Safety, Animal and Plant Health
IRAD	Institute of Agricultural Research for Development
ISAV	Infectious Salmon Anaemia Virus
ISPM	International Standards for Phytosanitary Measures
ISSG	Invasive Species Specialist Group
ITTA	International Tropical Timber Agreement
ITISs	Infrared Thermal Image Scanners
IUCN	International Union for Conservation of Nature
LANAVET	National Veterinary Laboratory
LLP	Low level presence
LMOs	Living Modified Organisms
LMO-FFPs	Living Modified Organisms intended for use as Food, Feed or Processing
MEAs	Multi-lateral Environmental Agreements
MEPC	Marine Environment Protection Committee
MINADER	Ministry of Agriculture and Rural Development

MINEE	Ministry of Water Resources & Energy
MINEPIA	Ministry of Livestock, Fisheries and Animal Industries
MINEPDED	Ministry of Environment, Protection of Nature and Sustainable Development
MINESUP	Ministry of Higher Education
MINFOF	Ministry of Forestry and Wildlife
MINTRANSPORT	Ministry of Transport
MINPOSTEL	Ministry of Post and Telecommunications
MINRESI	Ministry of Scientific Research and Innovation
MINSANTE	Ministry of Public Health
NBSAPs	National Biodiversity Strategies and Action Plans
NGOs	Non-Governmental Organizations
NPPO	National Plant Protection Organization
OIE	Organisation for Animal Health
PoE	Points of Entry
PCR	Polymerase Chain Reaction
PFAs	Pest Free Areas
PRA	Pest Risk Assessment
PMRP	Propagative Monitoring and Release Program
PSC	Port State Control
rDNA	Recombinant DNA
RM	Risk Management
RNQP	Regulated, non-quarantine pest
RPPOs	Regional Plant Protection Organizations
RAPID	Ruggedized Advanced Pathogen Identification Device
SARS	Severe Acute Respiratory Syndrome
SBSTTA	Subsidiary Body on Scientific Technical and Technological Advice
SCBD	Secretariat to the Convention on Biological Diversity
SOPs	Standard Operating Procedures
SPB	Strategic Plan for Biodiversity
SPF	Specific Pathogen Free
SPS Agreement	Agreement on the Application of Sanitary and Phytosanitary Measures
SSC	Species Survival Commission
STDF	Standards and Trade Development Facility
STEEEP	Social, Technical and Scientific, Economic, Environmental, Ethical, Policy & Political

TBM	Transboundary Movement
TBT	Technical Barriers to Trade
ToT	Training of Trainers
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
UNDP	United Nations Development Program
USDA	United States Department of Agriculture
VFZ	Vector Free Zones
WHO	World Health Organization
WTO	World Trade Organization
WWF	World Wide Fund for Nature

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EXECUTIVE SUMMARY

Project Purpose and Justification

The Cameroon Biosecurity Project (CBP) entitled "*Development and Institution of a National Monitoring and Control System (Framework) for Living Modified Organisms (LMOs) and Invasive Alien Species (IAS) is aimed at* increasing the capacity of stakeholders to prevent and control the introduction, establishment and spread of IAS and management of LMOs in Cameroon through the implementation of a risk-based decision making process. The project addresses four barriers as follows:

1. Ineffective policy, regulatory and institutional framework for the effective prevention and control of the introduction, establishment and spread of biological invaders,
2. Inadequate implementation of cost-effective risk-based biosecurity measures,
3. Insufficient capacity for a risk-based approach to biosecurity management and,
4. Lack of information to inform management and low levels of awareness among key stakeholder groups.

The project seeks to address these gaps through implementation of four interlinked components i.e.

i. **Component 1 (Policy & Regulatory Framework):** Establishment of policy and regulatory framework for effective prevention and control of the introduction, establishment and spread of biological invaders.
ii. **Component 2 (Implement sustainable biosecurity strategies):** Implement sustainable strategies for the risk-based management of priority pathways and species for IAS and LMOs.
iii. **Component 3 (Capacity Building):** Build capacity to enable the control of the entry, establishment and spread of IAS and management of LMOs.
iv. **Component 4 (Information and Awareness):** Raise awareness of key stakeholder groups on risks, impacts and management of IAS and LMOs.

Objectives of the Study

The objective of the activity was to develop a Training of Trainers Course in Inspection Systems and Methods including Treatments for Cameroon. The Project is aimed at raising awareness on inspection methods and best practice for treatment as part of an integrated risk-based approach to biosecurity amongst key stakeholder agencies in Cameroon including the country's 28 phytosanitary inspection posts. This is in recognition of the important role of preventing the introduction of invasive species as the first line of defence as part of a risk-based management system for biological invasions and the role that effective inspection systems play.

By the end of the training, trainees are expected to:

1. Understand inspection systems, inspection methods and treatment processes for movements of people and products into a country.
2. Have an overview of risk management analysis - selection of appropriate management options.
3. Understand inspection sampling methods and how they are used as a means of detection of a risk organism or its symptom.
4. Have an overview of the different treatment options available for different species / species types / commodities.

Methodology

In developing the Manual, the Consultants conducted a desktop review of National documents including legal and policy documents, documents produced under the CBP, Journals as well as documents developed by international organizations. Examples here include leading international agencies such as under the Convention on Biological Diversity (CBD), the Global Invasive Species Programme (GISP), the International Maritime Organization (IMO), the International Plant Protection Convention (IPPC), the Organization for Animal Health (OIE), the Food and Agriculture Organization (FAO), the World Trade Organization (WTO), the International Union for Conservation of Nature (IUCN).

Relevant material was drawn from these sources and consolidated into the Training Manual. Direct interviews were also conducted with experts and key personnel at stakeholder institutions in order to develop the Case studies on systems, processes and approaches applied in handling the recent Ebola and Avian influenza in Cameroon. An initial draft of the Manual was presented to the Component 2 Task Team. A Training of Trainers (ToT) Workshop was then held under the related Activity C6 (Component 3). Thirty (30) participants were selected to participate in the ToT Workshop. Participants were drawn from lead institutions responsible for various biosecurity sectors including government ministries, Research Institutions, Universities, Non-Governmental Organizations and others. The training methodology used was participatory involving Power Point Presentations, Group Work and Discussion. Following the workshop, the Manual was developed further using inputs and recommendations of participants at the ToT.

The Manual was presented to the Task Team for Component 2 and further refined based on their inputs.

Results

The synthesis of this process is presented in Five Modules as follows:

- Module 1: Review of Basic Concepts: This Module is a revision of basic concepts related to various biosecurity sectors.
- Module 2: The Institutional and Regulatory Framework for Management of Risk Pathways. This Module is aimed at enhancing the understanding of inspection systems, inspection methods and treatments processes for movements of people and products into a country.
- Module 3: Risk Analysis. This Module begins with a definition of Risk Analysis and its components i.e. Risk Assessment, Risk Management and Risk Communication.
- Module 4: Treatment Options. This Module considers treatment methods and various classes of pests and products they can be applied to.
- Module 5: Technical and Administrative Issues. This Module considers various technical and administrative issues involved in inspection.

Recommendations

A. **Preparation of guidance documents and Standard Operating Procedures:** There currently exists gaps in terms of detailed guidance in a number of key areas. It is recommended that the following are developed with utmost urgency:

   - Manuals for cleaning vehicles and equipment with particular emphasis on imports of used vehicles and agricultural equipment.
   - Guidelines for inspection and monitoring of contained use facilities working with LMOs, checklists and record forms
   - Guidelines for inspection and monitoring trials involving LMOs, checklists and record forms
   - Guidelines for post-release monitoring and surveillance of LMOs. The Manual on Biosafety Risk Assessment and Risk Management for Cameroon can form the basis for these with additional information based on current best practice.
   - Standard Operation Procedures (SOPs) to cover the range of inspection related functions across biosecurity sectors.

B. **Elaboration of thresholds:** Tolerance levels for Adventitious Presence and Low Level Presence for Cameroon need to be agreed on and elaborated through a legal instrument.

C. **Clear elaboration of protection goals and acceptable levels of protection to enhance effectiveness of Risk Analysis:** Protection goals in all sectors and the desired levels of protection must be clearly elaborated to assist with Risk Analysis.

D. **Integration and/or coordination of biosecurity and enhancing collaboration with the Customs Directorate:** This could be done through establishment of a single entity to coordinate biosecurity issues as suggested in (MINEPDED, 2015[2]) and a single, comprehensive Biosecurity Act. An example of this approach is New Zealand's Biosecurity System.

1. INTRODUCTION

Context and justification

The Cameroon Biosecurity Project (CBP) entitled "*Development and Institution of a National Monitoring and Control System (Framework) for Living Modified Organisms (LMOs) and Invasive Alien Species (IAS) is aimed at* increasing the capacity of stakeholders to prevent and control the introduction, establishment and spread of IAS and management of LMOs in Cameroon through the implementation of a risk-based decision making process. The Project consists of four interlinked components as shown in Table 1.

Table 1: Components of the Cameroon Biosecurity Project

Component	Description
Component 1 (Policy & Regulatory Framework)	Development of policy, regulatory and institutional framework for effective prevention and control of the introduction, establishment and spread of biological invaders (establish policy, regulatory and institutional framework)
Component 2 (Implement sustainable biosecurity strategies)	Implementation of sustainable strategies for the risk-based management of priority pathways and species for IAS and LMOs
Component 3 (Capacity building)	Build capacity to enable the control of the entry, establishment and spread of IAS and LMOs (Capacity building).
Component 4: (Information and awareness)	Raise awareness of key stakeholder groups on risks, impacts and management of IAS and LMOs.

Activity C6 (Training of Trainers in Inspection Systems and Methods Including Treatments and the Development of a Training Manual was carried out under Component 3 (Capacity Building) of the CBP.

Concepts

The CBP glossary defines Invasive Alien Species (IAS) as alien species which threaten ecosystems, habitats or other species where Alien species are those species that occur outside their normal distribution. It is generally accepted that movement of IAS is linked with human intervention and can be intentional or unintentional. Movement of species linked with human activity has been occurring for millennia. Not all alien species become invasive in the new area. The combination and interaction of the characteristics of the species with those of the receiving environment determine the invasiveness of an introduced species in its new environment. IAS species have been reported from all known taxa. These have serious effects across various biosecurity sectors. The CBP defines Biosecurity as a strategic and integrated approach that encompasses policies and regulatory frameworks that analyse and manage risks in the sector of food safety, animal life and health, and plant life and health, including associated environmental risk. It recognizes biosecurity as a holistic concept of direct relevance to the sustainability of agriculture and food production, food safety and the protection of the environment, including biodiversity and covers the introduction of plant pests, animal pests and diseases and zoonosis, the introduction and release of genetically modified organisms (GMOs) and their products, and the introduction and management of invasive alien species and genotypes".

The CPB refers to organisms that have been developed through modern biotechnology as Living Modified Organisms (LMOs). The use of "Living" as opposed to "Genetically" stresses the CPB's focus on ability to transmit or replicate genetic material as this could potentially result in negative impacts.

The Biosecurity continuum is an integrated approach to prevent, detect, contain, eradicate and/or minimize the impact of a pest, disease or other IAS through complementary biosecurity activities taken at various stages of the movement of the organism i.e. Pre-border, at the border and post-border. The glossary of terms used is included as Annex I to this document.

Aims and Objectives

The Project is aimed at raising awareness on inspection methods and best practice for treatment as part of an integrated risk-based approach to biosecurity amongst key stakeholder agencies in Cameroon including the country's 28 phytosanitary inspection posts. The objective is to develop a Training of Trainers Course in Inspection Systems and Methods including Treatments for Cameroon. By the end of the training, trainees are expected to:

- Demonstrate an understanding of inspection systems, inspection methods and treatments processes for movements of people and products into the country.
- Have an overview of risk analysis and selection of appropriate risk management options for various classes of bio-invaders.

- Have an overview of the different treatment options available for different species / species types / commodities.
- Understand inspection sampling methods and how they are used as a means of detection of a risk organism or its symptom.
- Understand the roles and responsibilities of various actors in an integrated biosecurity system.
- Examine and validate documentation accompanying imports.

It is anticipated that this will contribute towards enhanced capacity for management of IAS and LMOs in Cameroon.

Methodology

Development of the Manual was based on a desk-top review of a wide range of documents from diverse sources. These include:

- **National policy and legal documents:** National policy and legal documents across various Ministries involved with aspects of biosecurity;
- **Documents produced under the CBP:** Examples here include the Current Biosecurity Profile from Trade and other Activities of Cameroon (MINEPDED (2014); List of major invasive species in Cameroon (MINEPDED 2015[1]); Review of Biosecurity Agencies, Guidelines and Procedures (MINEPDED, 2015);
- **Publications:** Journals as well as documents developed by international organizations: Examples here include leading international agencies such as under the Convention on Biological Diversity (CBD), the Global Invasive Species Programme (GISP), the International Maritime Organization (IMO), the International Plant Protection Convention (IPPC), the Organization for Animal Health (OIE), the Food and Agriculture Organization (FAO), the World Trade Organization (WTO), the International Union for Conservation of Nature (IUCN).

The consultants synthesized this material into a Draft Manual that was presented to the Task Team for Component 2. The Manual was improved with inputs obtained from the Task Team and used as a basis for training 30 participants at a ToT workshop. The Wosrkhop was itself designed to be participatory and in addition to the training itself served to provide the consultants with input into the developing manual based on the experiences of participants gained through interaction at the workshop. Direct interviews were also conducted with experts and key personnel at stakeholder institutions in order to develop the Case studies on systems, processes and approaches applied in handling the recent Ebola and Avian influenza in

Cameroon. Following the workshop, the Manual was developed further and again presented to the Component 2 Task Team. Comments and inputs received from the Task Team were used to futher develop and finalize the Manual. The process of development of development of the Manual is as summarised in Figure 1.

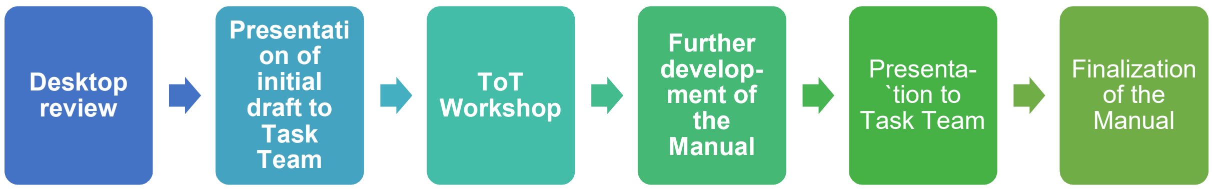


Figure 1: Process followed in development of the Manual

Results

- **Module 1: Review of Basic Concepts:** This Module begins with a pre-course knowledge survey then proceeds to revision of basic concepts related to various biosecurity sectors.
- **Module 2: The Institutional and Regulatory Framework for Management of Risk Pathways.** This Module is aimed at enhancing the understanding of inspection systems, inspection methods and treatments processes for movements of people and products into a country. It begins with a consideration of risk pathways in Cameroon and progresses to look at the international regulatory and institutional arrangements for biosecurity in the country. The National Biosecurity regime in Cameroon is also discussed. The final section of this module considers actions involved in control of bio-invasion across various biosecurity sectors with particular emphasis on control measures at points of entry.
- **Module 3: Risk Analysis.** This Module begins with a definition of Risk Analysis and its components i.e. Risk Assessment, Risk Management and Risk Communication. The application of Risk Analysis is then considered from different sectors beginning with Risk Analysis for import of terrestrial animals. Import Risk Analysis for aquatic animals is also considered. Pest Risk Analysis is also discussed followed by Risk Assessment of LMOs as plant pests. Environmental Risk Assessment (ERA) of LMOs as developed by the European Food Safety Authority (EFSA) is discussed briefly for plants and animals. Risk Assessment and Management for ballast ship water and

sediments is also discussed briefly. Risk Management and Risk Communication are also discussed.

- **Module 4: Treatment Options**: This Module considers treatment methods and various classes of pests and products they can be applied to.
- **Module 5: Technical and Administrative Issues.** This Module considers various technical and administrative issues involved in inspection. It begins with sampling methods and also considers roles and responsibilities for inspection across various biosecurity sectors. Technical and administrative requirements for inspectors are also considered.

Next Steps in Conformity with the CBP

It is expected that the Manual will be used to serve both as a technical and training document, that it will be disseminated to various stakeholders and serve as a reference document which everyone with an interest in IAS/LMOs Inspection and Treatment Processes use. It is a well-researched document and will not only serve those on the field, policy makers but also scholars. Despite the technical language used, it is hoped that the definitions provided will throw a lot of light to the issues raised. It is hoped that several training courses will be provided to key stakeholders and that the process need to be continuous taking into account the fact that users are not static. It is also anticipated that key institutions involved in the process will allocate adequate funding for training of trainers and other personnel.

Relationship to the Current Risk Assessment and Risk Management Manual

Cameroon has developed a Manual on Biosafety Risk Assessment and Risk Management (Koch, 2004). This Manual focusses on assessment and management of Risks associated with LMOs only. In this Manual, risk assessment is considered across all biosecurity sectors. With regards to LMOs, this Manual provides more detail on the methodology and consideration of LMOs destined for release into the environment as well as confined field trials based on current best practice.

1. MODULE I: REVIEW OF BASIC CONCEPTS

TIME REQUIRED: 1½ HOURS

Purpose: To facilitate a shared understanding of basic concepts related to IAS and their management.

Expected Outcomes: At the end of the Module, trainees should be able to:

- Distinguish between native and alien species,
- Define Invasive Alien Species,
- State common characteristics of IAS,
- Recognize factors that make habitats susceptible to IAS,
- Explain the invasion process,
- Understand zoonosis and related concerns,
- Define vectors and pathways as they relate to invasion by IAS.

This module revises basic concepts related to biosecurity and IAS. A number of sectors that are critical to human survival and the economy are linked to biosecurity. Each of these is threatened by specific invasive alien species that can have considerable impacts. This module introduces biosecurity and the various sectors represented. Key concepts related to IAS are discussed. It is important for inspectors to have a sound grasp of these concepts in order to be able to put their tasks into perspective. An understanding of what IAS are and the characteristics of IAS should enable inspectors to identify species that show such characteristics and thus pose more risks. Further, an understanding of the invasion process becomes useful in risk assessment of IAS. An understanding of the impacts of IAS should illustrate the urgency and importance of prevention and other measures for controlling the effects of IAS.

1.1. Pre-course Knowledge Assessment sample questions

A few sample questions are included here. Annex II includes a more comprehensive example pre-course knowledge assessment test.

1. **Which of the following refers to a species that has evolved in an area and occurs there naturally?**
   A. An exotic species
   B. A natural species
   C. A Native species
   D. An endemic species

2. **When a species that has been introduced into an area overwhelms naturally occurring species in that area, it is referred to as:**
   A. An indigent species
   B. An indigenous species
   C. An Invasive Alien Species
   D. An exotic species
3. **Which of the following statements is the most correct**
   A. All alien species introduced into an area are invasive
   B. Alien species that have been legally introduced into an area cannot be invasive
   C. Some alien species introduced into a new area will over time, become established and cause damage to biological diversity
   D. Effective border control can stop entry of all invasive species.
4. **The three stage hierarchy for management of Invasive Alien Species includes which of the following:**
   A. Inspection, treatment and release
   B. Inspection, early detection and treatment
   C. Prevention, early detection and mitigation
   D. Prevention, early detection and treatment
5. **Which of the following international organization/ instruments is not involved in biosecurity?**
   a. The Convention on Biological Diversity
   b. The United Nations Convention to Combat Desertification
   c. The International Plant Protection Convention
   d. The World Organization for Animal Health

1.2. Review of Basic Concepts

1.2.1. Introduction to biosecurity

Biosecurity refers to a strategic and integrated approach that encompasses the policy and regulatory frameworks for analysing and managing relevant risks to human, animal and plant life and health, as well as associated risks to the environment (FAO, 2007). Beale *et al.,* (2008) define biosecurity as the protection of the economy, the environment, social amenity, or human health from the negative impacts associated with the entry, establishment, or spread of animal or plant, pests and diseases, or invasive plant and animal species. Bingham *et* al., (2008) simply refer to Biosecurity as “making life safe”. Biosecurity encompasses a range of issues of concern including food safety, zoonosis, the introduction of animal and plant diseases and pests, the introduction and release of living modified organisms (LMOs) and their products as well as the introduction and management of invasive alien species (IAS) (FAO, 2007).

Of particular concern in the international arena is the transboundary movement (TBM) of commodities, live animals and plants, people and their goods, means of transportation etc. with the associated risks of biological invasions (bio-invasions). Bio-invasion refers to the accidental or intentional importation of harmful non-native organisms into new areas.

1.2.2. Zoonosis and public health concerns

Zoonosis refers to infectious diseases that can be transmitted naturally between humans and wild or domestic animals. A comprehensive review by Cleaveland *et al.*, (2001) identified 1,415 species of infectious organisms known to be pathogenic to humans, including 217 viruses and prions, 538 bacteria and rickettsia, 307 fungi, 66 protozoa and 287 helminths. Of the total number, 868 (61%) were zoonotic. A joint consultation involving the World Health Organization (WHO), the Food and Agriculture Organization (FAO) and the Organization for Animal Health (OIE) notes that more than three quarters of human diseases that are new, emerging or re-emerging at the beginning of the 21st century are caused by pathogens originating from animals or from products of animal origin (WHO/FAO/OIE, 2004; Jeggo, 2012) including emerging diseases that affect food safety and security (Jeggo, 2012).

Examples of serious biosecurity issues in public health over the past few years include:

- The Severe Acute Respiratory Syndrome (SARS) epidemic in 2003 which spread to at least thirty countries within just a few weeks of the first confirmed cases. In China and Canada, there were 5327 and 251 confirmed cases respectively. Sporadic cases were reported in Singapore, Vietnam, Thailand, Australia and other countries (WHO, 2003).
- The *Aedes aegypti* mosquito is a vector for the Zika virus and viruses that cause diseases such as chikungunya, dengue fever, Yellow fever etc.
- Avian influenza (bird flu): This refers to viral infections in birds. Most strains do not affect humans but two have been reported to infect humans. These are A(H5N1) and A(H7N9).
    - Concerns about these stem first from their effects on poultry and hence productivity systems and trade, and;
    - Downstream effects on global health.

1.2.3. Alien vs native species

Native species are those species that occur in an area either because they have naturally evolved there or, they have become established in that area with **no human intervention**. Native species whose distribution is limited to a specific area are described as **endemic** to that area. Oceans, mountains, rivers and deserts have historically provided biogeographical barriers which have effectively ensured isolation of species and ecosystems (de Poorter, 2003).

Human beings have transported and traded plant and animal species for many millennia. Polynesians sailed with pigs, taro, yams, and at least 30 other species of plants as well as rats and lizards as stowaways. Similarly, the Asians who first peopled the Americas also brought dogs with them (McNeely, 2001). This movement of species continued with periods of increased activity coinciding with the industrial revolution in Europe in the 1800s and extending into other areas of the world linked with the migration of European settlers thereafter (Preston *et al*., 2004 in Hulme, 2009). The highest rates of introductions in Europe were recorded in the -last 25 years and this is expected to increase in future due to globalization (Hulme, 2009). The effectiveness of natural isolation barriers has thus been eroded in just a couple of hundred years mainly due to trade, travel, transport and tourism linked with economic globalization (de Poorter, 2003).

Alien species are defined as those taxa that are introduced outside of their natural range either intentionally or unintentionally by human agency. When alien species become established in the new environment, proliferate and spread in ways that are destructive to native ecosystems, human health, and ultimately human welfare they are referred to as **Invasive Alien Species (IAS).** Along with climate change, IAS present two of the greatest threats to biodiversity and the provision of valuable ecosystem services (Burgiel & Muir, 2010; Katsanevakis *et al.,* 2014). IAS occur in all major taxonomic groups including viruses, fungi, algae, mosses, ferns, higher plants, invertebrates, fish, amphibians, reptiles, birds and mammals. Within each group, numerous species, including as many as 10% of the World's 300,000 vascular plants are capable of invading other ecosystems (McNeely *et* al., 2001; Rejmánek et al., 2000).

Invasive alien species have invaded and affected native biota in virtually every ecosystem type on earth (McNeely *et* al., 2001). The distribution of taxa recorded in the International Union for Conservation of Nature's (IUCN) Top 100 of the World's Worst Invasive Species by organism type (Lowe *et al.,* 2000) is shown in Figure 2.

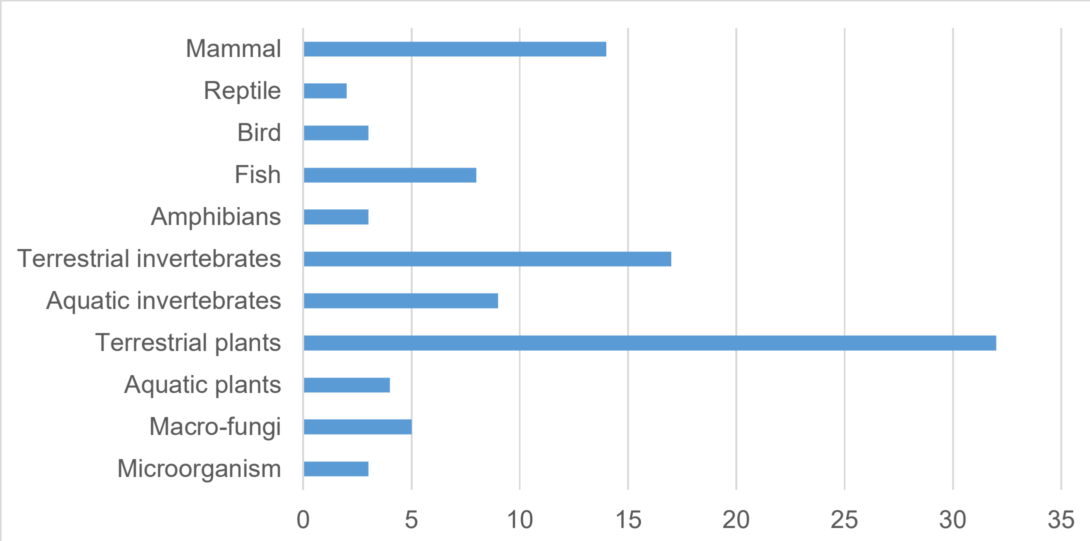


Figure 2: Number of species by type included in IUCN's Top 100 invasive species List

In Cameroon, the distribution of species by taxa recorded in the recently completed survey as invasive is shown in Table 2.

Table 2: Distribution of invasive species by species type in Cameroon

Type of taxon	**Examples**	**No. on updated list**
Crop pests and diseases	• *Aspergillus flavus* • Root node Nematode • Maize weevil • Silverleaf whitefly	109
Invasive plants	• *Echonochloa pyramidalis* • *Chromolaena odorata* • *Pennisetum purpureum* • Bracken Fern	36
Animal & human diseases	• Foot and Mouth Disease Virus (FMDV) • Human Immunodeficiency Virus (HIV) • *Vibrio cholera*	26
Aquatic life & vertebrates	• *Quelea quelea*	11
Total		**164**

Based on MINEPDED (2015[1])

1.2.4. Characteristics of IAS

A range of factors may be involved in determining whether or not a species introduced into a new area will be invasive. Factors that contribute to an alien species establishing and becoming invasive include:

- **Lack of natural enemies (predators, parasites, competitors and pathogens) that control the species in its native range:** In many cases, the introduced species is introduced into the new area without its natural enemies. This allows it to establish in the new environment.
- **Rapid growth and prolific reproduction:** Many IAS are capable of reproducing very quickly. First, they often reach reproductive age quickly. Second, they are often capable of producing large numbers of offspring per reproductive cycle.
- **Phenotypic plasticity (ability to adapt physiologically to new conditions):** IAS are usually able to tolerate a wide range of conditions and are also able to use a wide food sources and resources i.e. most IAS are highly adaptable.
- General characteristics of IAS are:
  - High reproductive rates,
  - Short time to maturity and reproduction,
  - Ability to live in diverse environments,
  - Tendency to be associated with human activities and environmental disturbances,
  - Good dispersal abilities, and,
  - Ability to outcompete native species.

Species that have become invasive in one area are likely to become invasive in another area (CISR, 2014).

1.2.5. Factors that contribute to invasiveness

The Invasive Species Specialist Group (ISSG) of the IUCN identifies the following as factors that contribute to increased invasiveness:

- Degradation of natural habitats, ecosystems and agricultural lands due to pollution, loss of soil cover etc. Many invasive species are “colonisers” in nature and are able to benefit from lack of competitors that follows degradation,
- Climate change e.g. increased temperatures may enable invasive mosquitoes to extend their range,
- Extreme weather conditions such as hurricanes, cyclones which increase the dispersal of IAS and their **propagules,**
- Inadequate knowledge and sharing of information amongst regulatory agencies,
- Poorly developed legal and institutional systems for control of IAS, and
- Inadequate public awareness (ISSG, 2000).

1.2.6. Not all introduced species become invasive

Not all species become invasive when introduced into a new area. The tens rule gives that of every hundred species introduced into a new area, 10% are likely to get established. Of these 10% are likely to be invasive i.e. only one of every 100 introduced species is likely to be invasive (Williamson, 1996; Keller *et al*., 2011). The tens rule was initially proposed for terrestrial plants but in animals, it has been suggested that proportions of introduced species that establish and become invasive may be as high as 50% (Jeschke & Strayer, 2005; Jeschke, 2008; Keller *et al.,* 2011).

1.2.7. Invasion-prone habitats

Based on an extensive survey of literature, Stohlgren & Schnase (2006) suggest the following habitats are more prone to invasion by IAS:

- Islands in decreasing order of susceptibility
    - Tropical islands
    - Temperate islands
    - Subarctic islands
    - Artic islands
    - Habitats high in native species diversity e.g. lowlands close to the coast, riparian zones, estuaries.
- Terrestrial and aquatic habitats high in light, nutrients, water, and warm temperatures
- Disturbed habitats (e.g. burned areas, ploughed fields); corridors (roads, stream channels, landslides),
- Habitats near heavily invaded sites (i.e. high sources of propagules, source populations),
- Areas with high levels of trade and transportation of invasive species (e.g. ports),
- Areas near commercial interests that sell plants, animals, seeds, bait, or containers or materials that harbour invasive organisms.

NOTE

Not all invasive species are alien. Some native species are capable of spreading beyond their natural range into new ecosystems within the country where they have negative effects.

1.2.8. Invasion Process

The invasion process involves three main phases as shown in Figure 3.

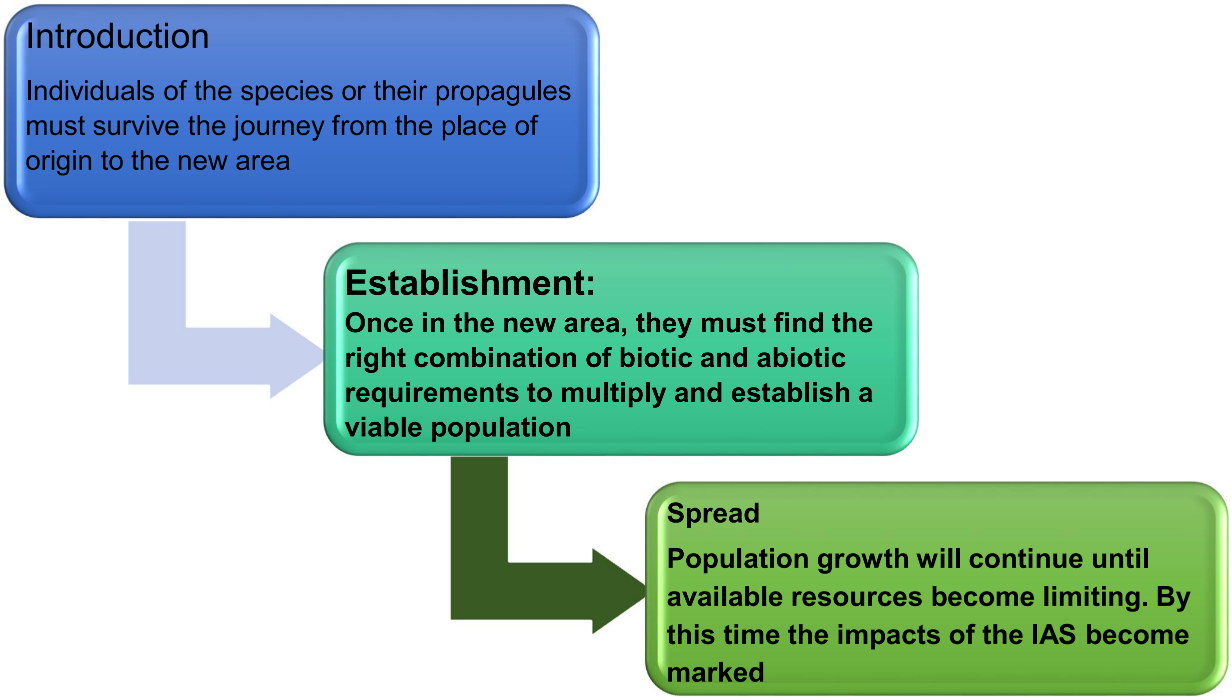


Figure 3: The invasion process

Some IAS undergo an initial phase of slow growth during which they may not have noticeable effects as spread is low. This is called the lag phase. The lag phase is defined as the delay between arrival of an introduced species and its successful spread in a new area (Daehler, 2009). The length of the lag phase depends on the species concerned, prevalent environmental conditions as well as the propagule pressure. It may be as short as a few years or in some cases, the lag phase may extend over several decades (Bean, 2015). Daehler (2009) reports lag phases of 5 years for herbaceous tropical invaders and 14 years for woody plants based on experimental plantings in Hawaii. The lag phase is followed by a period of explosive population growth during which rapid dispersal and spread into favourable habitat occurs (Le Roux, 2008). This continues until resources become limiting i.e. the carrying capacity is reached as shown in Figure 4.At this stage, most available and suitable habitat has been occupied (Le Roux, 2008) thus growth slows down as the available space becomes saturated (Arim *et al.,*2006). As the size of the population of the IAS grows, it begins to have various effects that impact on the equilibrium of the ecosystem.

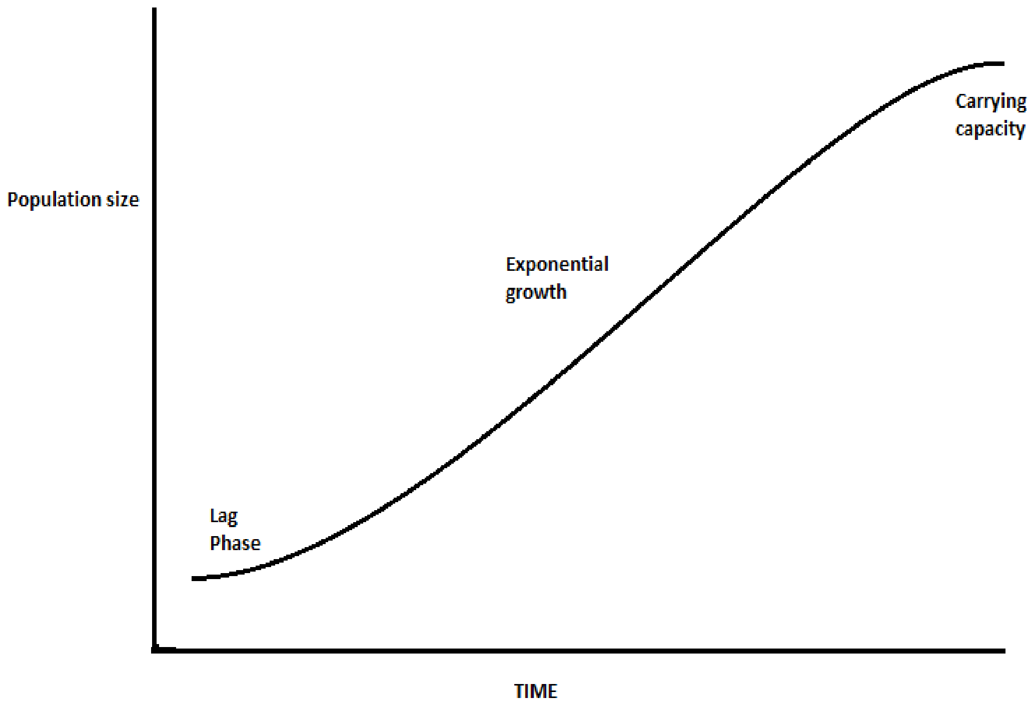


Figure 4: Stages in the invasion process

1.2.9. Consequences of establishment of Alien species

Consequences of entry, establishment, and spread of non-indigenous species in new environments can range from:

- **Beneficial:** Many crops of economic importance are not native to the countries they are produced in. In many cases these were introduced into those areas. The introduction of many species for use as crops, ornamental species, domestic livestock, and uses in horticulture, forestry and other sectors has resulted in huge benefits for mankind.
- **Benign:** Many species introduced into new environments are neither beneficial nor detrimental in the new environment.
- **Detrimental:** Some alien species become detrimental in the new environment. They may cause damage to the ecosystem, economy, public health and they also pause a risk to individual species. Examples of detrimental impacts of IAS are summarised in Table 3 and Figure 5.

Table 3: Examples of detrimental impacts of IAS

ISSUES AND EXAMPLES	SOURCE (S)
i. IMPACTS ON BIOLOGICAL DIVERSITY (GENETIC AND SPECIES)	
Hybridizing with native species thus compromising their genetic integrity and threatening locally adapted races	Marambe et al, (2011) Yakandalawa & Yakandala, 92011).
Direct predation e.g. *Harmonia axyridis* leading to a decline of native ladybirds in the United Kingdom and Europe	Brown *et al.,* (2011) *Roy et al.,* (2012)
(*Oxyura jamaicensis*) hybridising with the endangered native white-headed duck (*Oxyura leucocephala*) in Spain.	Hulme *et al*, (2016)
Modification of population structure e.g. in South Africa, shading due to invasion of river beds by *Chromalaena odorata* has been reported to be altering sex ratio in Nile crocodiles.	Leslie & Spotila (2001)
2. ALTERING ECOSYSTEM STRUCTURE & FUNCTION	
• Altered fire regimes • Altered energy flows resulting from changes in trophic interactions e.g. reduction of aquatic plant populations in wetlands in South Asia by Golden apple water snails • Altered productivity due to increase of IAS that use resources more efficiently or replace the most dominant form	Brooks *et al.,* (2004) Carlsson et al. (2004) Dukes & Mooney (2004)
3. IMPACTS ON ECOSYSTEM SERVICES:	
Impacts on provision of biomass from the marine environment for human consumption including all industrial, artisanal and recreational fishing activities and aquaculture.	Katsanevakis *et al.,* 2014
Deterioration of water quality	Walsh *et al.,* (2016).
Impacts on infrastructure e.g. • Clogging water pipes used for electric power plants and municipal and irrigation water supplies by zebra mussels and Quagga mussels, • Damage to infrastructure causing frequent power outages	 Ministry of Natural Resources, (2005) Schwiff *et al*., (2010)
Impacts on ecosystem goods services e.g. deterioration of water quality	Chamier *et al*., 2012
Impacts on health e.g. introduction of alien infectious agents	Weinhold (2010)

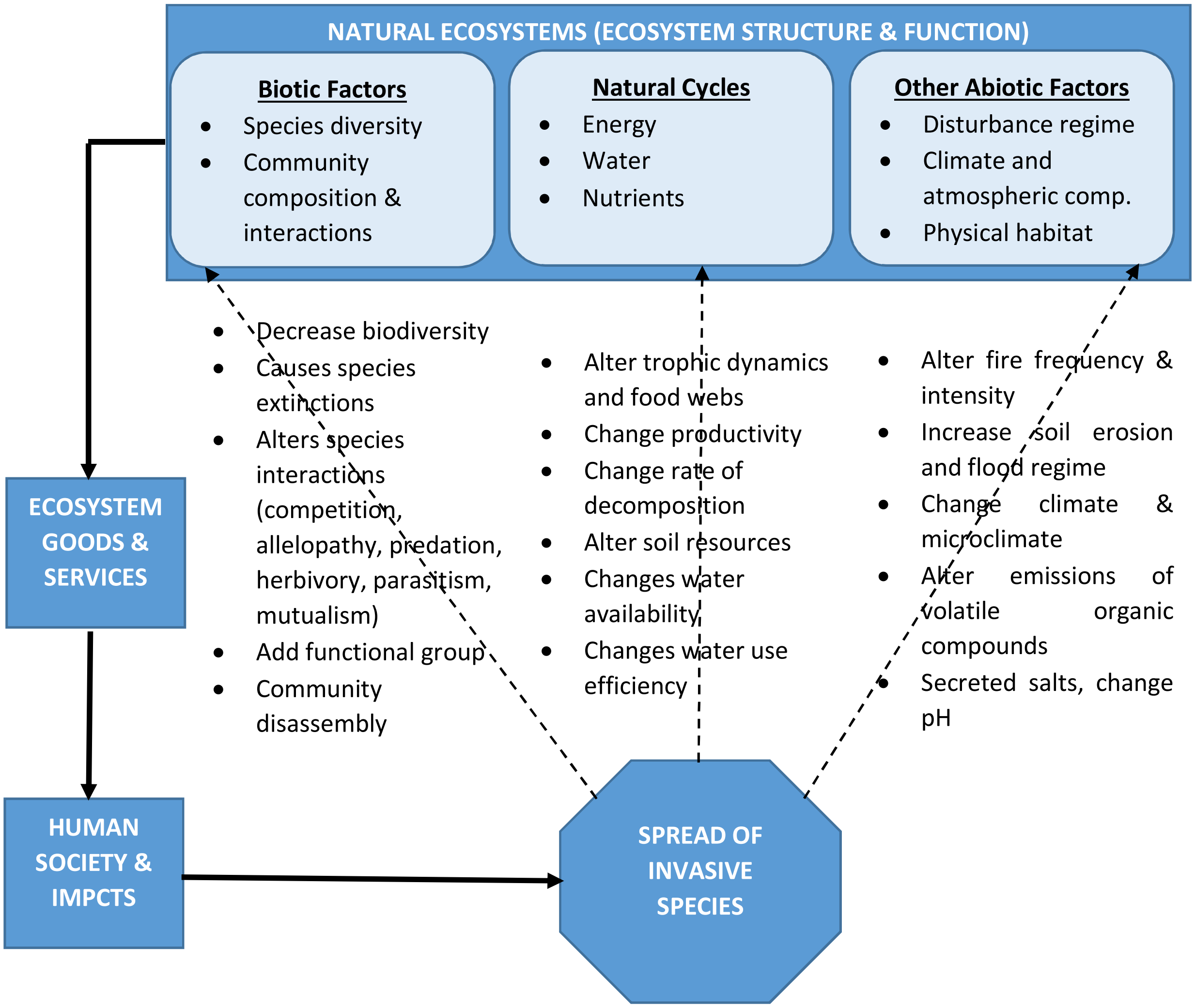


Figure 5: Impacts of IAS and effects on Ecosystem services

(From Charles & Dukes, 2008)

1.2.10. Pathways and vectors

Hulme *et al*, (2008) recognize six broad classes of pathways by which species may be introduced. These are:

- Deliberate release,
- Escape from captivity;
- Contaminant of a commodity;
- Stowaway on a transport vector;
- Via an infrastructure corridor (without which spread would not be possible) or,
- Unaided from other invaded regions (Hulme *et al.*, 2008).

(UNEP/CBD, 2014) advocated a standard categorization system to identify pathways of IAS introduction on the grounds that this would ensure a consistent and effective prioritization of IAS pathways and the identification of the most appropriate measures for their management. The document entitled “Pathways of introduction of invasive species, their prioritization and management” proposes a distinction between a number of IAS pathways:

- Intentional and/or unintentional introductions,
- The introduction mechanism as either:
    - The importation of a commodity,
    - The arrival of a transport vector,
    - The establishment of an anthropogenic dispersal corridor, or,
    - The natural spread from a region where the species is itself alien.

These mechanisms can further be divided into six main groups i.e. Release; Escape; Transport- Contaminants; Transport-Stowaway; Corridors; and Unaided (natural dispersals) as shown in Table 4.

Table 4: Categorization of pathways for the introduction of alien species

	Category	Sub-category
MOVEMENT OF COMMODIDTY	Release in Nature	Species released for biological control erosion control
		Dune stabilization (windbreaks, hedges)
		Fishery in the wild (including game fishing)
		Hunting in the wild
		Landscape/flora/fauna “improvement” in the wild
		Introduction for conservation purposes
		Release in nature for use (other than above, e.g., fur, transport, medical use)
		Other intentional release
	Escape from Confinement	Agriculture (including Biofuel feedstocks)
		Aquaculture / mariculture
		Botanical garden/zoo/aquaria (excluding domestic aquaria)
		Pet/aquarium/terrarium species (including live food for such species)
		Farmed animals (including animals left under limited control)
		Forestry (including reforestation)
		Fur farms
		Horticulture
		Ornamental purpose other than horticulture
		Research and ex-situ breeding (in facilities)
		Live food and live bait
		Other escape from confinement
		Live food
		Live bait

MOVEMENT OF COMMODIDTY		Contaminant nursery material
		Contaminated bait Food contaminant (including of live food)
		Contaminant on animals (except parasites, species transported by host/vector)
		Parasites on animals (including species transported by host and vector)
		Contaminant on plants (except parasites, species transported by host/vector)
		Parasites on plants (including species transported by host and vector)
		Seed contaminant
		Timber trade
		Transportation of habitat material (soil, vegetation)
VECTOR	**Transport - Stowaway**	Angling/fishing equipment
		Container/bulk Hitchhikers in or on airplane
		Hitchhikers on ship/boat (excluding ballast water and hull fouling)
		Machinery/equipment People and their luggage/equipment (in particular tourism)
		Organic packing material, in particular wood packaging
		Ship/boat ballast water
		Ship/boat hull fouling
		Vehicles (car, train, …)
		Other means of transport
SPREAD	Corridor	Interconnected waterways/basins/seas
		Tunnels and land bridges
	Unaided	Natural dispersal across borders of invasive alien species that have been introduced through pathways 1 to 5

Unintentional introduction of IAS often result from international trade where organisms arrive in new areas as stowaways on ships, planes, trucks, shipping containers, attached to packing materials, on unprocessed logs, fruits, seeds, and vegetables and nursery stock (Office of Technology Assessment, 1993; McNeely, 2001). One of the most important ways in which IAS are unintentionally introduced into new areas is through ballast ship water.

Conventional types of trading ships use ballast tanks to prevent heavy rolling and capsizing, but also to achieve adequate propulsion, steerage, forward visibility and maximum fuel efficiency. As they fill-up their ballast tanks, any living organisms in the surrounding water, including fish in various stages of development, crustaceans, molluscs, algae, viruses, bacteria etc. are also taken into tanks and transported around the world to be deposited wherever the ship discharges its ballast tank to load as shown in Figure 6.

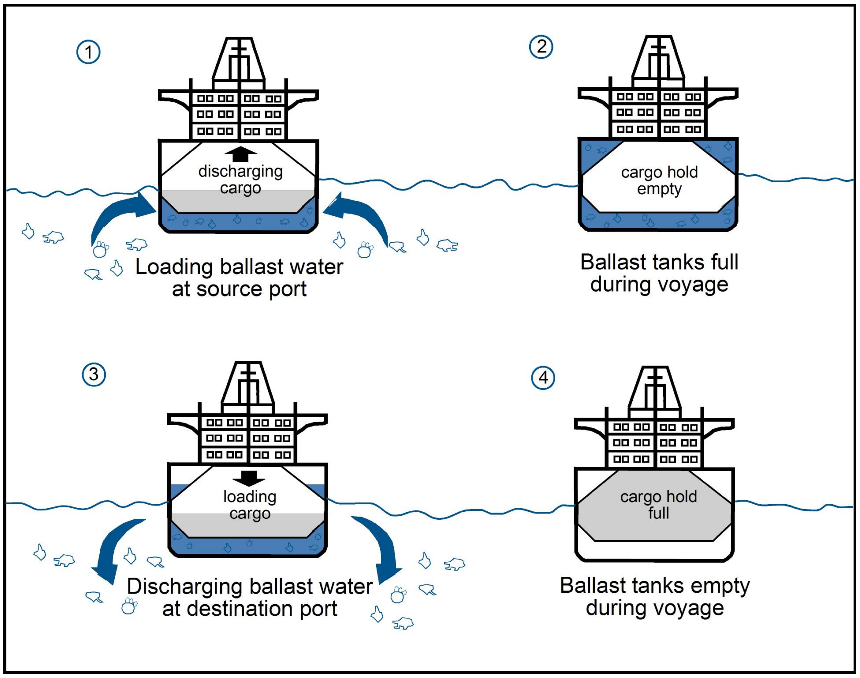


Figure 6: Illustration of ballast water and unintentional movement of IAS

http://lms.seos-project.eu/learning_modules/marinepollution/marinepollution-c04-p05.html

The World Wide Fund for Nature (WWF) estimates that 7000 marine coastal species travel in this manner daily (WWF, 2009). Ballast water is now regarded as the most important vector for trans-oceanic and inter-oceanic movements of shallow-water coastal (ISSG, 2000). There are numerus cases of IAS that are causing significant damage around the world that entered those areas with ballast water. An example is the introduction of Zebra mussels (*Dreissena polymorpha*)from Eurasia into North American waters. Species may also be unintentionally introduced into new areas by people when organisms or propagules become attached to clothing, luggage or means of transportation.

A **pathway** is defined as the means (e.g. aircraft, vessel or person), purpose or activity (e.g. farming, shipping or pet trade), or a commodity (e.g. fisheries) by which an alien species may be transported to a new location, either intentionally or unintentionally. The actual physical means, agent or mechanism which facilitates the transfer of an organism or its propagules from one place to another is referred to as a **vector**.

1.3. Living Modified Organisms

Advances in molecular biology have enabled development of techniques that effectively enable scientists to alter the genetic makeup of organisms to manipulate its characters. In particular, modern biotechnology which as defined in the Cartagena Protocol on Biosafety

(CPB) is limited to use of techniques that overcome natural physiological reproductive or recombination barriers which are not used in traditional breeding and selection (SCBD, 2000). This includes a much narrower range of technologies that involve movement of genetic material across species boundaries that would not normally occur in nature. Organisms produced by such techniques are referred to as Living Modified Organisms (LMOs). LMOs possess a novel combination of genetic material obtained through the use of modern biotechnology techniques. Another term that is used is Genetically Modified Organism (GMO). Whilst these two are often used interchangeably, GMOs actually include both living and dead entities whereas as the name suggests, LMOs refers only to entities that are capable of passing on genetic material to the next generation.

1.3.1. Recombinant DNA Technology

Recombinant DNA (rDNA) is one of a number of techniques that can be used to move DNA across unrelated species. The process involves a number of steps as shown in Figure 7. An organism that carries the gene of interest must first be located in nature. This can be any organism. Genomics is making it increasingly easier to identify genes as the understanding of gene function and structure increases. Once the donor organism has been identified, the gene can be isolated from the donor organism. This is done using enzymes called **Restriction enzymes**. These are enzymes that recognize specific sequences and cut DNA at those sites.

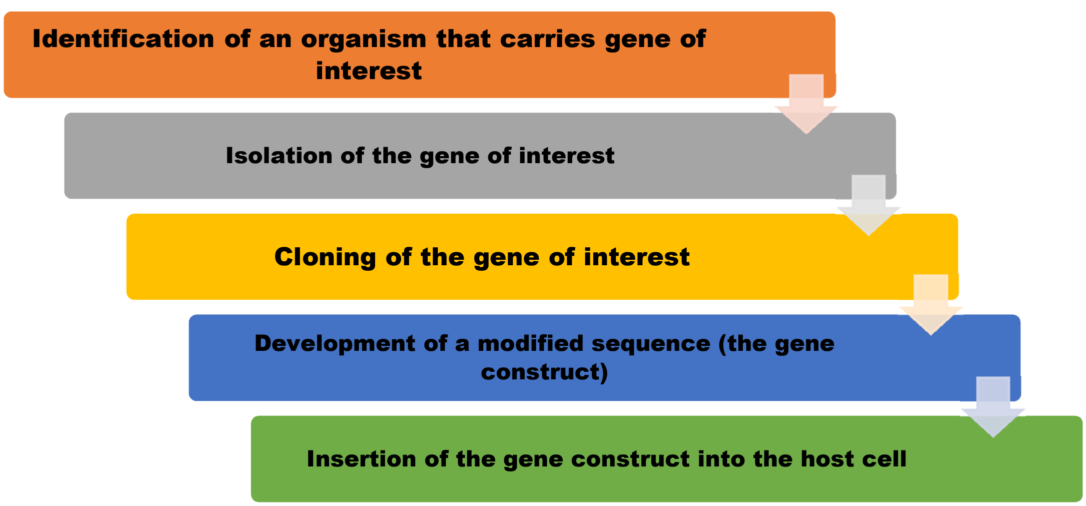


Figure 7: Steps in rDNA technology

Having isolated the gene, it must then be cloned (i.e. production of many copies of the gene) in a vector. A modified construct is then prepared by adding a number of sequences to the gene as shown in Figure 8.

Promoter	Coding Region	Terminator sequence	Marker Gene

Figure 8: The transgene construct

i. **The promoter sequence:** The promoter regulates expression and function of the gene. Enhanced expression can be obtained by modifying the sequence slightly.
ii. **The coding region:** This is the specific gene to be introduced.
iii. **The terminator sequence:** This sequence signals to the machinery of the cell that the end of the gene has been reached.
iv. **The marker gene:** Only a very small fraction of cells will be able to express the gene of interest. Inclusion of a marker gene makes it easier to identify cells that have been transformed. The marker gene can be for herbicide resistance, antibiotic resistance such as kanamycin and neomycin.

1.3.2. Applications and Benefits of Modern Biotechnology and its products

Modern biotechnology has found applications in a range of sectors including medicine, pharmaceuticals, food and nutraceuticals, agriculture, industrial and environmental applications. Indeed the use of modern biotechnology as a basis for producing industrial enzymes, chemicals and pharmaceuticals is a huge and booming business internationally. In the United States, bio-based pharmaceuticals account for the largest share of the biotechnology market. The European Union, China, India, and Brazil are also important players. The value of bio-based chemical products exceeded US$60.5 billion in 2007 in China alone (Tang & Zhao, 2009).

Applications in crop agriculture have found the widest application to date. In 2014, more than 181 million hectares of GM crops were grown by 18 million farmers in 28 countries (James, 2014). This involved commercial seven traits i.e.

- **Abiotic Stress Tolerance**e.g. Monsanto's Genuity® DroughtGard™ produced by inserting the *cspb* gene (encodes the cold shock protein B which maintains normal cellular functions under water stress conditions)
- **Altered Growth/Yield**e.g.genetically modified (GM) *Eucalyptus* produced for higher volumetric growth by inserting a gene from *Arabidopsis thaliana*.

- **Disease Resistance e.g.** GM *Phaseolus*, GM papaya and GM potato produced to resistant to specific diseases.
- **Herbicide Tolerance**e.g. Herbicide tolerant maize (126 events), soybean (34 events), cotton (40 events), Argentine canola (31 events) etc.
- **Insect Resistancee.g.** GM maize (119 events),
- **Modified Product Quality:** Examples here include GM maize produced for enhanced bioethanol production, GM maize produced for enhanced lysine content, petunias produced for novel colours etc.
- **Pollination control system:** Examples include GM soybean produced to be male sterile (see www.isaaa.org.gmapprovaldatabse).

In the animal sector, examples of the application of modern biotechnology include:

- **GM salmon**: GM salmon has been developed by inserting a gene that regulates the growth hormone obtained from Chinook salmon and a promoter from an ocean pout into salmon. The transgene enables year round growth hence enabling GM salmon to grow up to eleven times faster than wild-type salmon. GM salmon thus reach market size within 18months rather than three years as is the case with conventional salmon. GM salmon also mature more rapidly are able to reproduce in less than two years (Smith *et al.,* 2010).
- **Ornamental GM Fish:** Some ornamental fish e.g. Zebra fish and Japanese rice have been genetically modified by incorporating genes that code for fluorescent proteins. These proteins make the scales of the fish glow hence the name GloFish.

1.3.3. Potential biosecurity concerns with LMOs

Potential concerns with LMOs are shown in Table 5.

Table 5: Potential concerns with LOMs

Risks for the environment	• Persistency of gene or transgene (volunteers, increased fitness of LM crop, invasiveness) or of transgene products (accumulative effects); • Susceptibility of non-target organisms; • Change in use of chemicals in agriculture; • Unpredictable gene expression or transgene instability (gene silencing); • Environmentally-induced (abiotic) changes in transgene expression; • Ecological fitness; • Changes to biodiversity (interference of tri-trophic interactions); • Impact on soil fertility/soil degradation of organic material;

Gene transfer	• Through pollen or seed dispersal & horizontal gene transfer (transgene or promoter dispersion); • Transfer of foreign gene to micro-organisms (DNA uptake) or generation of new live viruses by recombination (transcapsidation, complementation, etc.);
Risks for animal and human health	• Toxicity & food/feed quality/safety • Allergies; • Pathogen drug resistance (antibiotic resistance), • Impact of selectable marker;
Risks for agriculture	• Resistance/tolerance of target organisms • Weeds or super weeds • Alteration of nutritional value (attractiveness of the organism to pests); • Change in cost of agriculture; • Pest/weed management; • Unpredictable variation in active product availability; • Loss of familiarity/changes in agricultural practice

Key points

- Biosecurity refers to a strategic and integrated approach that encompasses the policy and regulatory frameworks for analysing and managing relevant risks to human, animal and plant life and health, as well as associated risks to the environment.
- Zoonosis is of key importance in public health as more than three quarters of human diseases that are new, emerging or re-emerging at the beginning of the 21st century are caused by pathogens originating from animals or from products of animal origin.
- Invasive Alien Species are species that are introduced outside of their natural range either intentionally or unintentionally by human agency, become established in the new environment, proliferate and spread in ways that are destructive to native ecosystems, human health, and ultimately human welfare.
- IAS occur in all major taxonomic groups and have affected native biota in every ecosystem type.
- An estimated 10% of introduced plants and as many as 50% of introduced animal taxa become invasive in the new area.
- The impacts of an introduced species in the new area are determined by:
    - The characteristics of the species
    - The receiving environment
- IAS may move into new areas via a range of pathways and vectors including intentional and unintentional movements. These mechanisms are largely linked to trade and transport of commodities, tourism, travel and transportation of people.

- Living Modified Organisms are organisms whose genetic material has been altered through modern biotechnology techniques are capable of transmitting DNA to the next generation.

End of Module Revision and Application Questions

Question 1

Ballast ship water is not the only means by which aquatic Invasive Alien Species can be introduced. What other ways can you think of? ______________________________

____

____

____

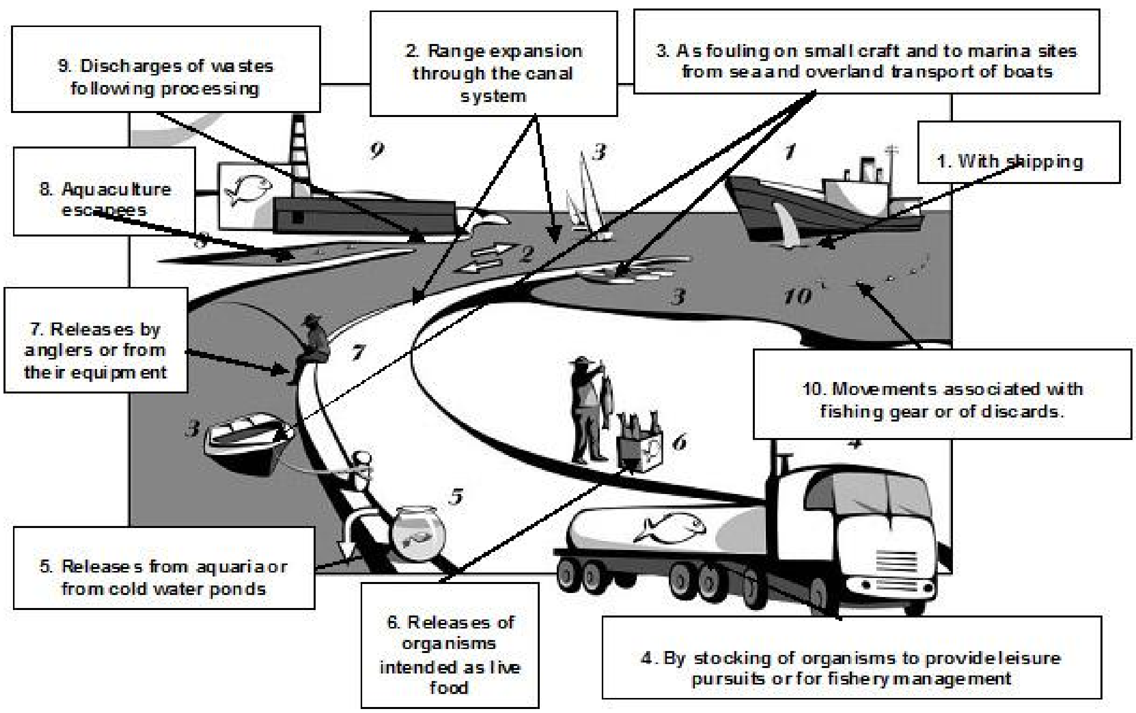
Question 2

Study the picture overleaf. This picture represents other pathways and vectors for introduction of aquatic IAS.

How many of the illustrated pathways and vectors were you able to identify? ____________

____

What key actions are required to prevent introduction of IAS by these vectors and pathways?



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QUESTION 3:

Distinguish between native and alien species.

QUESTION 4

List five factors that contribute to alien species becoming established and invasive.

QUESTION 5

List three factors that make habitats prone to invasion

QUESTION 6

Distinguish between a pathway and a vector

2. MODULE II: THE INSTITUTIONAL AND REGULATORY FRAMEWORK FOR MANAGEMENT OF RISK PATHWAYS

Purpose: To enhance the understanding of inspection systems, inspection methods and treatments processes for movements of people and products into a country.

Format: PowerPoint Presentations, Group discussion and Group activities.

Expected Outcomes: By the end of the session, trainees will be able to:

- Define "pathways" and "vectors"
- Name some high risk species in Cameroon including their pathways and vectors
- Explain the international biosecurity institutional and regulatory framework,
- Describe the current regulatory and institutional biosecurity framework,
- By the end of the module, trainees will be able to describe inspection methods applied in different inspections systems.

2.1. Risk pathways and vectors for the introduction of potentially invasive species into Cameroon

A study on the Current Biosecurity Profile from Trade, Transport, Travel and Tourism was carried out under the CBP.The study was aimed at identifying the main risk pathways for species introduction into Cameroon with a view to facilitating identification of appropriate risk management strategies (MINEPDED, 2014). The study analysed import permit requests from ninety two companies (92) involving 116 plant species over a 28 month period. Three pathway groups were identified as shown in Table 6.

Table 6: Pathway groups identified in Biosecurity Profile Study

Group and description	Level of Risk
Group 1: Vegetative Material Imported for Consumption (Fresh Fruit And Vegetables)	Products generally short-lived though. Apart from the risk of fruit flies, this group is thought to present the lowest risk.
Group 2: Seeds for Sowing	Seed imports are generally sourced from the same sources who have an established track record. Risks of seed-borne diseases are thus not likely to be high
Group 3: Vegetatively propagating Material for Growing	No Specific concerns are raised.

In terms of the main risk products and pathways, the study notes the following:

- High risk products are identified as onions and other alliums such as garlic and shallots, beetroots, brassicas, citrus, cucurbits, tomato and potatoes.
- Because of different pest profiles, products arising from South America and Asia including Citrus and Cucurbits from China and Kiwis from Argentina are identified as high risk products.
- Grain imports may present risks depending on treatment method and storage used.
- No concerns are raised with invasive fish apart from species used for bait as indications are that there are no imports of live fish into the country. The bulk of fish imports is in the form of frozen fish.
- The report notes the lack of a national animal quarantine facility as a concern (MINEPED, 2013).

The report also notes the following:

- **Animals and animal products:** Imports of live animals are relatively low (an average of 23 tonnes per year). A large quantity of fish and crustaceans is imported (an average of 132,264 tonnes per year).
- **Vehicles:** Large numbers of vehicles and tractors are imported (an average of 77,350 vehicles per year). Used/ second-hand vehicles and farm machinery/ equipment pose the risk of contamination with soil which may also contain weed seeds and other potentially invasive species. The risks of import of weeds and infected solids can only be managed through thorough cleaning of the tractors and machinery. Similar risks would apply to agricultural machinery, which is not specifically listed. There is no set procedure for dealing with this risk at the ports of import (MINEPDED, 2014).

Earlier studies carried out within the framework of the CBP have resulted in the development of a black list, white list and grey list of invasive species for Cameroon. The list portrays the magnitude or scale of harm the species therein contained can cause if imported and if rapid measures are not put in place to prevent, control, eradicate or manage species found on it.

A recent report by the National Ports Authority indicates that food imports to Cameroon for 2015 stood at 1.388 Tonnes with rice alone at 729,822 Tonnes. Frozen fish stood at 217,140 tons whilst other food stuffs accounted for 301,510 tons.
By July, 2016 exports of bananas stood at 152,384 tons
SOURCE: K44/October 2016 Business in Cameroon

- **Black list species:** The black list contains species which if released in the open environment would have very high negative impact on human, animal or plant health. These are species that cannot be imported into the country.
- G**rey list:** Species contained in this list are not as highly dangerous to human health, animal and plant. They however need surveillance.

2.2. International institutions and obligations for management of risk pathways

2.2.1. The World Health Organization

The World Health Organization (WHO) is the directing and coordinating authority on international health issues under the United Nations system. WHO supports member countries in coordination of all efforts to attain their health objectives and support their national health policies and strategies (see www.who.int).

In an effort to address the threat of global spread of vectors and vector-borne diseases, through points of entry (PoE), International Health Regulations (IHRs) were developed in 1969. Under these regulations, Member States were required to notify to WHO of any disease outbreaks or other public health emergencies of international concern within 24 hours. In 2005, the World Health Assembly adopted new International Health Regulations (IHR, 2005), which came into force in July 2007 (WHO, 2016). The IHRs are aimed at prevention, protection, control and provision of a health response to the international spread of diseases whilst minimising undue restrictions on international traffic and trade (WHO, 2016). Annex1 of the IHRs requires countries to develop core capacities to respond to events that may constitute a public health emergency of international concern (Gaber, 2009; WHO, 2016).

2.2.2. The World Trade Organization

The World Trade Organization (WTO) replaced its predecessor the General Agreement on Tariffs and Trade (GATT) on January 1, 1995 also bringing into effect the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) negotiated in 1994 at the end of the Uruguay round of multilateral negotiations. The SPS Agreement allows countries to enforce measures to prevent the spread of plant, animal, or other disease agents, and to prevent or control the spread of pests provided the measures used are based on scientific justification or on an objective assessment of the risks to human, animal or plant health (WTO, undated[1]; Doyle *et al.,* 1996; Hayes, undated; Rigod, 2013). The SPS Agreement also encourages members of the WTO to base their regulations on health and safety standards developed by the three relevant international expert bodies (WTO, undated[1]) i.e.

- The Codex Alimentarius Commission (CAC) for food safety related issues,
- The International Plant Protection Convention (IPPC) for plant health issues, and,
- The World Organisation for Animal Health (OIE) for animal health related issues.

Another relevant Agreement under the WTO is the Agreement on Technical Barriers to Trade (TBT). Its aim is to ensure that technical regulations, standards, and conformity assessment procedures are non-discriminatory and do not create unnecessary obstacles to trade. It also recognizes the rights of states to put in place technical regulations to fulfil objectives such as national security, prevention of deceptive practices, protection of human health or safety, animal or plant life or health, or the environment (WTO, undated[2]).

2.2.3. The Food and Agriculture Organization

The Food and Agriculture Organization of the United Nations (FAO) is an intergovernmental organization comprised of 194 Member States and one member organization, the European Union (EU) as well as two associate members. Together with eradication of hunger, food insecurity and malnutrition, its goals are sustainable management and utilization of natural resources. In addition to facilitating a neutral forum for negotiations on food and agriculture related issues, the FAO serves as a repository for information and also provides member states with technical assistance in the core areas of agriculture, forestry and fisheries practices. With particular reference to biosecurity, the FAO hosts the Secretariat of the IPPC and has also, together with other organizations established the International Portal on Food Safety, Animal and Plant Health (IPFSAPH) which serves as a single access point for the latest version of international and national standards, regulations, and other official materials relating to Sanitary and Phytosanitary (SPS) measures in food and agriculture including fisheries and forestry (FAO, 2016) See http://www.fao.org/biosecurity/ and http://www.ipfsaph.org/

The FAO has also developed a range of guidance documents in the area of biosecurity.

2.2.4. The International Plant Protection Convention

The International Plant Protection Convention (IPPC) dates back to 1952. It is a multi-lateral agreement for cooperation in plant protection. Its objective is to secure common and effective action to prevent the spread and introduction of pests of plants and plant products, and to promote appropriate measures for their control though adoption of legislative, technical and administrative measures (FAO, 1997). The IPPC requires each member state to establish a National Plant Protection Organization (NPPO) whose functions include:

- Issuance of phytosanitary certificates for consignments that meet the phytosanitary requirements,
- Surveillance of growing plants both in fields, plantations, nurseries, gardens, greenhouses and laboratories, wild flora, as well as plant products in storage or in transportation,
- Inspection of consignments of plants and plant products moving in international traffic and, where appropriate, the inspection of other regulated articles, particularly with the object of preventing the introduction and/or spread of pests; and;
- Disinfestation or disinfection of consignments of plants, plant products (FAO, 1997).

The Secretariat of the IPPC facilitates development of internationally agreed standards related to phytosanitary measures in international trade with intent to prevent and control the spread of plant pests including those that are IAS. The IPPC has 182 Parties. The Secretariat of the IPPC has developed 37 standards related to plant pest control. Since 1999, the IPPC has attempted to clarify its role with regards to IAS that are plant pests as reflected in the revision in 2003 of the International Standards for Phytosanitary Measures (ISPM) 11 on Pest risk analysis for quarantine pests including analysis of environmental risks (de Poorter, 2003). See https://www.ippc.int/static/media/files/publications/en/2013/06/03/13742.new_revised_text_of_the_international_plant_protection_201304232117en.pdf

The IPPC also provides for the establishment of Regional Plant Protection Organizations (RPPOs). In Africa, this is the Inter-African Phytosanitary Council (IAPSC). The European and Mediterranean Plant Protection Organization (EPPO) has set up a Working Group on Invasive Species. In addition to developing a list of invasive alien plants the EPPO has also elaborated a regional standard on analysis of environment risks.

2.2.5. The World Organization of Animal Health

The World Organization of Animal Health generally referred to as the OIE (from Office International des Epizooties) is the main intergovernmental organisation responsible for issues related to animal health worldwide and is also recognized as a reference organisation by the WTO. It was established initially by 24 countries in 1924 and now has 180 Member countries and also maintains permanent relations with 71 other international and regional organizations (WTO, 2016). Its mandate has been expanded to encompass new animal health issues including the role of wildlife in the spread of diseases, animal welfare, food safety risks arising from animals and infectious disease issues at the human-animal interface (Kahn& Pelgrim, 2010). The OIE does not specifically address IAS-related risks presented by animals and has not, to date, developed standards related to IAS. It has however issued guidelines related to IAS. Also, three of the OIE-listed animal health diseases are recognized by the CBD as IAS that threaten biodiversity. The Standards and Trade Development Facility (STDF) notes a gap with regards to the international regulatory framework related to animals that are neither plant pests nor listed by the OIE as pathogens and parasites (STDF, 2013), also noted by COP IX of the CBD through Decision IX/4 (SCBD, 2009).

2.2.6. The Convention on Biological Diversity

The Convention on Biological Diversity (CBD) is the major international instrument that focuses on biological diversity (biodiversity). The objectives of the CBD are the conservation of biological diversity, sustainable use its components and the fair and equitable sharing of benefits arising out of the utilization of genetic resources. Article 8(g) of the CBD invites contracting Parties to establish or maintain means to regulate, manage or control the risks associated with the use of LMOs resulting from biotechnology which are likely to have adverse environmental impacts that could affect the conservation and sustainable use of biological diversity, taking also into account the risks to human health.

Article 8(h) of the CBD requires contracting parties to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species (United Nations, 1992). During the Seventh Conference of the Parties (COP)held in 2002, Parties to the CBD agreed on and adopted a set of non-binding *Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species that Threaten Ecosystems, Habitats or Species* with the aim of assisting countries to minimize the spread and impact of IAS (SCBD, 2002; STDF, 2013). The Guiding Principles are non-binding in nature but seek to provide governments and organizations with guidance, clear direction and common goals for developing effective strategies to minimize the spread and impact of IAS whilst allowing them to develop context specific solutions (Shine, 2005). Principle 2 elaborates a three-stage hierarchical approach to management of IAS as shown in Table 7.

Table 7: Representation of Guiding Principle 2

CONTAINMENT AND CONTROL (MITIGATION)	Where eradication is not feasible or resources are not available, containment and long-term control measures should be implemented.
EARLY DETECTION	If an invasive alien species has been introduced, early detection and rapid action are crucial to prevent its establishment: The preferred response is to eradicate the organisms as soon as possible.
PREVENTION	Prevention of movement of IAS between and within states is generally far more cost-effective and environmentally desirable than measures taken after introduction and establishment of IAS. Examples of actions include risk analysis, import regulation, management of border areas etc.

(Based on Lopian, 2005; Shine, 2005 & SCBD/GIASI Partnership)

As part of their obligations under the CBD, Parties are required to prepare and implement National Biodiversity Strategies and Action Plans (NBSAPs) which are effectively an elaboration of how they plan to implement the provisions of the CBD at national level. Cameroon became Party to the CBD on 19th October, 1994 when she deposited her instrument of ratification. She has revised her NBSAP and has also submitted five National Reports on the implementation of the CBD (see https://www.cbd.int/countries/default.shtml?country=cm).

The Subsidiary Body on Scientific Technical and Technological Advice (SBSTTA) is an open-ended intergovernmental scientific advisory body established by Article 25 of the CBD. The SBSTTA provides the COP and its appropriate bodies with advice to support implementation of the Protocol (McNeely, *et al.,* 2001). The CBD further established the Global Environment Facility (GEF) which provides funding to Parties to support biodiversity related projects. Issues related to IAS are a major item on the SBSTTA's agenda.

The Strategic Plan for Biodiversity (SPB) and its Aichi targets adopted by Parties to the CBD in 2010 during COP X provides an overarching framework on biodiversity the entire United Nations system as well as all other partners engaged in biodiversity management and policy development. Target 9 of the SPB states "By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment" (SCBD, 2010).

2.2.7. The Cartagena Protocol on Biosafety

The Cartagena Protocol on Biosafety of the Convention on Biological Diversity (CPB) was adopted by the COP of the CBD in Montreal in January 29, 2000 and opened for signature in May 2000 in Nairobi. To date, the CPB has a total of one hundred and seventy (170) parties (SCBD, 2015). The objective of the CPB is to contribute to the safe transfer, handling, and use LMOs produced through modern biotechnology that could adversely affect the conservation and sustainable use of biological diversity taking into account risks to human and animal health (SCBD, 2000; Kalaitzandonakes, 2006). Whilst this is the primary objective of the CPB, it also establishes an international regime for regulating trade in LMOs (Müler, 2004; Serdaroğlu, 2011).

The CPB establishes the Advance Informed Agreement (AIA) procedure which requires a party wishing to export an LMO into another country to notify the country of import prior to the first export of the LMO. It also requires the country of export to make full information on the LMO available to the importing country to enable the country of import to conduct risk assessment and make a decision accordingly. The AIA procedure however exempts some classes LMOs.

Cameroon ratified the CPB on 11th September, 2003 and has submitted 3 National Reports on implementation of the CPB. She has also enacted a national biosafety law as part of her domestication measures (See http://bch.cbd.int/database/record.shtml?documentid=10787).

2.2.8. The International Maritime Organization

The International Maritime Organization (IMO) of the United Nations is a global standard setting authority on issues of safety, security and environmental performance of international shipping including prevention of pollution by ships. The IMO has promoted the adoption of about 50 conventions and protocols and has also adopted more than 1,000 codes and recommendations on issues related to its mandate (See www.imo.org). Of particular relevance to IAS is the International Convention for the Control and Management of Ships' Ballast Water and Sediments, also called the Ballast Water Management (BWM) Convention. The BWM Convention was adopted in 2004 following fourteen years of negotiation. It seeks to prevent the spread of harmful aquatic organisms by establishing standards and procedures for the management and control of ships' ballast water and sediments. The BWM Convention will enter into force on 8 September 2017 (IMO, 2016).

The IMO has also developed Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species(Biofouling Guidelines) through Resolution MEPC.207(62). The Biofouling Guidelines seek to provide a globally consistent approach to the management of biofouling. They were adopted by the Marine Environment Protection Committee (MEPC) at its 62nd session in July 2011 following three years of consultation between IMO Member States (MEPC, 2011). Cameroon has not as yet ratified the BWM Convention but indications are that arrangements towards this are in progress.

2.2.9. The United Nations Convention on the Law of the Sea

The United Nations Convention on the Law of the Sea (UNCLOS) is aimed at providing a global framework of cooperation in the area of prevention and management of IAS. It requires Member States to work together "to prevent, reduce and control human caused pollution of the marine environment, including the intentional or accidental introduction of harmful or alien species to a particular part of the marine environment (IMO, 2016). Cameroon became party to UNCLOS on 19th November, 1985.

2.2.10. The Convention on International Trade in Endangered Species of Wild Flora and Fauna

The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) is aimed at facilitating international cooperation in regulating international trade of endangered plant and animal species. Cameroon was the 68th country to become party to CITES. During the CITES COP X held in Harare, the Parties adopted two decisions with a bearing on IAS i.e. Decisions 10.54 and 10.76 regarding trade in alien species and directed to the Parties and to the Animals Committee (AC) respectively. Decision 10.54 encourages Parties to recognise that species traded under the Convention are likely to be introduced into new habitats and thus pose significant threats to biodiversity. In this respect, it urges Parties to consider the problems of invasive species when developing national legislation and regulations related to trade in live animals or plants; to further consult with the relevant Management Authority of a proposed country of import, when possible and when applicable, when considering exports of potentially invasive species, to determine if there are domestic measures regulating such imports. Another aspect of the decision was to encourage Parties to consider opportunities for synergy between CITES and the CBD, and further explore appropriate cooperation and collaboration between the two Conventions on the issue of introductions of Alien (Invasive) Species (CITES, 2004).

2.2.11. The International Tropical Timber Agreement

The International Tropical Timber Agreement (ITTA) seeks to promote expansion and diversification of international trade in tropical timber from sustainably managed and legally harvested forests and to promote the sustainable management of tropical timber producing forests. It encourages members to develop national policies aimed at sustainable utilization and conservation of timber producing forests, and maintaining ecological balance, in the context of the tropical timber trade.

2.2.12. The International Union for Conservation of Nature

Unlike the other organizations, the International Union for Conservation of Nature (IUCN) is a membership-based organization composed of government and civil society organizations (CSOs). Its main role is to provide stakeholders in environment related issues including the public, private and Non-Governmental Organizations (NGOs) with knowledge, guidance and tools in support of human progress, economic development and nature conservation. The IUCN has established a number of specialist networks of volunteer experts from all over the world. Among these is the Species Survival Commission (SSC) under which the Invasive Species Specialist Group (ISSG) works. The ISSG is a global network of scientific and policy experts on invasive species.

SOURCES OF IAS Related information

The Global Invasive Alien Species Information Partnership (GIASIPartnership)
http://giasipartnership.myspecies.info/en (Still under development)
Global Invasive Species Database (GISD) found on http://www.iucngisd.org/gisd/

2.2.13. The Agreement on the Conservation of African-Eurasian Migratory Water Birds

The Agreement on the Conservation of African-Eurasian Migratory Water Birds (AEWA)is an intergovernmental treaty dedicated to the conservation of migratory waterbirds and their habitats across Africa, Europe, the Middle East, Central Asia, Greenland and the Canadian Archipelago. AEWA covers 254 species of birds ecologically dependent on wetlands for at least part of their annual cycle, including many species of divers, grebes, pelicans, cormorants, herons, storks, rails, ibises, spoonbills, flamingos, ducks, swans, geese, cranes, waders, gulls, terns, tropic birds, auks, frigate birds and even the South African penguin. Under this agreement, interim guidelines (*Interim Conservation Guidelines on the avoidance of introductions of non-native migratory water bird species*) were adopted in September 2002. These Guidelines provide a common framework for avoiding introductions of alien migratory water birds. They further recommend development and adoption of a standard risk assessment methodology for particular species in the context of the regional landscape (see http://www.unep-aewa.org/). Cameroon is listed as a Non-Party Range State.

2.3. National regulations for management of risk pathways

The government of Cameroon is party to several multilateral environmental agreements (MEAs) relating to the conservation of biological diversity. Some of these international treaties oblige parties to undertake measures aimed at ensuring that activities undertaken within their borders do not produce harmful impacts on the national territories of other parties. Other MEAs ensure that contracting parties adopt strict phyto-sanitary measures in order to prevent the intentional/voluntary introduction of pests into other member countries as well as measures that do not hinder free movement of goods and persons or impose discriminatory trade measures on other parties.

Cameroon is also a gateway to other landlocked countries in the central African sub region, thus goods destined to neighbouring countries like Chad, Central African Republic, Congo, Sudan do transit through Cameroonian seaports and sometimes through the territory by land.. The porous nature of the terrestrial borders of Cameroon exposes it to undocumented trade from its other six neighbouring states (Nigeria, Equatorial Guinea, Central African Republic, Gabon, Chad, and Congo).

International trade has been cited as one of the four Ts which are pathways for the introduction of invasive alien species into a country, the others being Transport, Travel and Tourism. Globalisation has provided global benefits of improved transportation which fosters trade, facilitated movements of persons and goods from one country/continent to another and many people are using recreation to explore new lands through tourism. These have serious negative impacts on biodiversity as species are intentionally or unintentionally moved from one ecosystem to another or country to another. Some of the species transported by air, sea and land transport move freely from plants to animals and from animals to humans, producing untold consequences on human health, animal health and on the environment. Sea transportation by ships involves the use of ballast water which carries with it living organisms from one port to the other. Millions of organisms are moved from one country to another each day through ballast water. Trade, transport, travel and tourism are the major pathways through which species move from other countries to Cameroon.

The prevention of potential or real loses posed by non-native species introduction on new habitat is costly especially to developing countries like Cameroon, so the government places priority on building the legal and institutional capacity towards an integrated system of biosecurity management of invasive alien species. Capacity required for carrying out efficient inspection to prevent introduction of invasive alien species or manage LMOs whether at airports, sea ports (04), or terrestrial borders by either customs, phyto-sanitary officials, forestry/wildlife, fisheries/livestock, environment, health officials is insufficient, thus a need to train trainers or available personnel for an integrated inspection system.

Key institutions such as the Ministry of Agriculture and Rural Development (MINADER), Ministry of Environment, Protection of Nature and Sustainable Development (MINEPDED), Livestock, Fisheries and Animal Industries (MIENEPIA), Ministry of Forestry and Wildlife (MINFOF); Ministry of Public Health (MINSANTE), Ministry of Finance (Customs Directorate General) and Agency for Quality and Standards (ANOR) do have inspection systems in place geared towards prevention of introduction of biological invasions in Cameroon. This sectoral approach to invasive species management has not produced the desired results, thus the need for putting into place a comprehensive integrated approach to biosecurity. The CBP was conceived to address this challenge.

The National regulatory framework for the management of IAS derives its source from the Constitution which is the supreme law of the land. It also derives its source from international Agreements and Treaties duly ratified by the government of Cameroon in the field of IAS. It is composed of legislation, Decrees and Orders. Adopted policies pave the way for their enactment.

Table 8outlines the key pieces of legislation and other regulations relating to IAS most of which are sector specific and flags out the key lead institutions championing their implementation including weaknesses.

Table 8: List of Principal Legal Instruments relating to IAS in Cameroon and lead implementation Institutions

Legal instrument	Area of IAS covered	Weakness	Proposal
Constitution of Cameroon	Preamble: every person shall have a right to a healthy environment. The protection of the environment shall be the duty of every citizen. The State shall ensure the protection and improvement of the environment.	Insufficient sensitization and information sharing	Improve on environmental education/ sensitisation
MINEPDED			
Law No. 96/12 of 5th August 1996 relating to environment management	Chap. II on General obligations	All implementation Decrees not yet adopted;	Biosecurity law to be included in the Decrees to be elaborated
Law No. 2003/006 of 21 April 2003 to lay down the safety regulations governing modern biotechnology	Regulates the transboundary movements of LMOs into Cameroon after a prior informed consent; risk assessment	No provision of incentives for use of LMOs	Insufficient public sensitization; need for a comprehensive biosecurity law where biosafety issues are part and parcel.
Decree No. 2007/0737/PM of 31 May 2007 on biotechnology application;	Application and approval of Genetically Modified Organisms (GMOs) and LMOs	Lack of sensitization or awareness creation on existence of this text	Biosecurity Programme to create general awareness on this issue
MINADER			
2003/003 on phyto-sanitary and pesticides management Legislation			Need to strengthen the capacity of phytosanitary posts and training of officials
Law No. 2001/004 of 23 July 2001 relating to Seed production and Marketing	Quality Seed production , marketing ensuring standards and inspection for agricultural seeds	Phytosanitary and pesticides	Weak capacity of phytosanitary infrastructure
Decree No. 2005/0771 laying down modalities for the functioning of	Elaborates the modalities for the functioning of plant quarantines	28 quarantine posts exist throughout the country and are in a poor state	Poor public awareness on appropriate use of pesticides (thus most treatment is based on spray and pray)

Legal instrument	Area of IAS covered	Weakness	Proposal
plant quarantine operations			
Decree No. 2005/0771 laying down modalities for the exercise of plant quarantine operations	Elaborates the modalities for the exercise of plant quarantine	Institution functions at the Macro level whereas structures on the ground are lacking	Need to create and render operational more phytosanitary structures
Decree No. 2005/0770 of 6 April 2005/PM of 6th April 2005 laying down the modalities for phytosanitary measures	Measures based on International standards	Poor implementation of quarantine measures due to lack of infrastructure and well trained staff	Capacity building needed
Decree No. 2005/0769/PM of 6 April 2005 organising the National Phytosanitary Council	Fixes the composition and Membership	Institution functions at the Macro level whereas structures on the ground are lacking	Need to create and render operational more phytosanitary structures
2003/003 on phyto-sanitary and pesticides management Legislation			Need to strengthen the capacity of phytosanitary posts and training of officials
MINFOF (for forests issues): Ministry in charge of Forestry and Wildlife (flora and Fauna) ensures protection of protected areas from invasive species; (insects and birds) and other endangered species protection through implementation of international conventions such the Convention on Migratory Species (CMS), CITES, including the ITTA convention as well as working with riverine communities to ensure management of these protected areas.			
Law no 94.94-01 of 20 January 1994 to lay down Forestry, wildlife and fisheries regulations. Regulates forests and wildlife biodiversity, creation of protected areas for conservation of rare and threatened species of wildlife, (Art 17) , delivery of permits for importation of live plants (Art. 15 of Decree no. 95-531 of 3 August 1995 laying down	Ministry works with local communities. Once they discover a new biological invasion, they quickly inform the park managers; the provision of incentives to local communities for their role in protecting the protected area and securing ecosystem benefits; promotes sustainable management of park resources;	Poor financing of protected areas leads to inadequate inspections and control; most invasive plant species like *Chromolaena odorata* are fond in protected areas; Institution is more directed towards what plant species live the country than those entering; control points are established at	Need for proper financing of protected Areas in Cameroon; adequate sensitization of riverine populations and other stakeholders into management of such areas; Reinforcement of protected Areas inspection and management; training of rangers and other workers in inspection, identification and monitoring of invasive species in parks; Need for placing focus on species entering the

Legal instrument	Area of IAS covered	Weakness	Proposal
modalities of application of the forestry law (identification of IAS in protected areas and monitoring		various borders but the infrastructure is very remote; Lack of marine Protected Areas	country rather than on those leaving the country.
MINISTRY OF TRADE			
Law on incentives to Trade	Provides incentives to establishing a business in Cameroon by reducing the period for the acquisition of relevant business licence		Law seeks to increase the influx of goods (bulk) into the country. More IAS could be introduced if stringent biosecurity measures are not instituted.
MINEE/ANOR			
Draft Law on Food Quality Control	This law ensures safety of food from all sources for human and animal health	Bill is awaiting to be tabled before Parliament	Consultation on Bill was not extensive, therefore need for intensive sensitization
MINEPIA (Livestock and fisheries issues) In charge of Animal breeding, Fisheries and Animal Industries. Plays an important role in the prevention of animal diseases, and fishery standards. This institution is the focal Ministry OIE (standards for animal protection and diseases prevention- safety. It is the Vice Chair of the National Committee on the fight against emerging and re-emerging zoonosis. (Avian influenza, African Swine Fever, Ebola).			
-94/01 law on Forestry, Wildlife and Fisheries (Art. 137) confers mandate on sanitary inspections and control of fishery products (detection, Identification and monitoring; -Ministerial Order no. 028/CAB/PM of 4th April 2014 laying down the creation, organisation and functioning of the National Program for the Prevention and fight against Emerging and Re-emerging Zoonosis	Ministry is the National focal Point for IOE; Animal, fisheries and animal products Animals, fisheries and animal products safety Fishery products safety Inspection, detection, identification and monitoring of zoonosis) through the National Veterinary Laboratory (LANAVET) Infrastructure	Program not fully functional (government budgetary allocation still expected).	Need for Government to provide resources and tap on available bi/multilateral resources from donors. Program needs to be well carried out with adequate stakeholder sensitization.

Legal instrument	Area of IAS covered	Weakness	Proposal
Decree no 2002/071 of 17.1.2002 fixing norms of conditioning and transporting fishery products	Art 4. All containers for conveying fishery products shall be accompanied by a description indicating the name, trade mark or installation number of the mareyage, scientific name and commercial name of the species, the weight of products conveyed, the number of the conformity certificate. 2) The species name shall conform to the nomenclature approved by an Order of MINEPIA. Art. 20 of the Decree requires an accompanying sanitary certificate for all conveyance of fishery products.	Poor implementation of provisions of this Decree	Due to the constant deficiencies in food quality of animal products, the draft law on quality control was drafted to correct the defects of this Decree.
MINSANTE			
National Program on HIV/AIDS	Sensitization, identification and treatment of Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome (HIV/AIDS)	Campaigns have to be continuous	More and more people still infected, insufficient medication in rural areas; need for more campaigns towards target populations, sufficient trained human resources to carry out detection and treatment.
Ministerial Order No. 028/CAB/PM of 4th April 2014 laying down the creation, organization and functioning of the National Program for the Prevention and fight against Emerging and Re-emerging Zoonosis	Sensitization on Avian flu and Ebola, polio. It ensures immunization of persons against certain biological invasions such as Polio, Yellow fever, meningitis, Ebola, etc. Inspections of none vaccinated persons at land borders, sea	Campaigns have to be continuous or ongoing and not only done when there is a break out of the biological invasion.	As the vice President of the One Health Program, the Ministry of Health should be more aggressive in its fight against zoonosis; Mobilise funding for emerging diseases and spear head the fight against major invasions; ensuring stakeholders collaboration.

Legal instrument	Area of IAS covered	Weakness	Proposal
	borders and airports especially for yellow fever, polio for young children from five years below; The Ministry of Health uses the Pasteur Institute situated in Yaoundé to carry out diagnostics and then treatment is done in most of the hospital structures. For invasions relating to animal diseases, treatments are done in the facilities concerned. Vaccination on yellow fever and trial vaccines on Ebola viruses, health structures at the border play this role.		
MINRESI: This institution charged with the promotion of Scientific Research and Innovations through its various Organisms like Institute for Agricultural Research and Development (IRAD), Institute for the Promotion of Medicinal Plants (IMPM) and National Centre for the Development of Technologies (CNDT). It promotes agricultural research, research on medicinal plants and technologies which can be beneficial to Cameroon, plays a major role in inspections and treatments of IAS as well as in LMOs development. It is currently working on a national policy on modern biotechnology.			
	MINRESI works with Researchers at various stations situated over the national territory in identifying various biological invasions (weeds, pests, aquaculture, animal breeding) and carries out research in improving agricultural production. Local plants and animal varieties are enhanced for rapid and high yield.	Lack of adequate funding, insufficient incentives to scientists, high mobility of scientist fleeing the country constitute a major setback	Prioritize Research and Scientific innovations to promote work on IAS and LMOs management; train and maintain scientists in these fields.

Legal instrument	Area of IAS covered	Weakness	Proposal
SODECOTON: (A para-public institution in charge of the promotion of cotton production in the country which has engaged in confined field trial of GM cotton)			
The legal instrument in this aspect is the Order creating the National Biosafety Committee which is championing inspections of the GM cotton in the confined fields with members of the inter-Ministerial Committee.	GM cotton field trials have provoked a lot of enthusiasm from cotton producers. Increased number of producers involved in field trials; SODECOTTON ensures security of the area and is the lead institution after MINEPDED which chairs the Biosafety Inter-Ministerial Committee.	Need for Organisation to enter open field trial and production of GM cotton to enhance crop yield; Irregular inspections due to high cost of inspection;	Need for the adoption of a legal collaboration agreement between Government of Cameroon, the Para-statal SODECOTTON and the community of rural growers to strengthen collaboration.

Source: Literature review and national consultant's data collection

2.4. Inspection systems, methods and treatments for movement of people and products

The Biosecurity continuum presents a framework for a mutually complementary range of risk management actions aimed at preventing the negative impacts of IAS (Magarey *et al.,* 2009) along the movement of the organism from the country of origin to the country of destination. Table 9 shows examples of actions that can be carried out at each step.

Table 9: Biosecurity Continuum and examples of actions

PRE-BORDER	BORDER		POST-BORDER
• Inspection prior to export • Testing prior to export • Treatment prior to export • Production from plants of specified phytosanitary status (e.g. from virus-tested plants or under specified conditions) • Inspection or testing in the	• Documentation checks • Verification of consignment integrity • Verification of treatment during shipment • Phytosanitary inspection • Testing • Treatment • Detention of consignments	•	• Detention in quarantine e.g. post-entry quarantine facility for inspection, testing or treatment • Detention at a designated place pending specified measures • Restrictions on the distribution or use of the consignment (for

growing season prior to export • Origin of the consignment from a PFA/ APPs • Accreditation procedures • Maintenance of consignment integrity. • Pre-clearance • Import Risk Analysis • Pest Risk Analysis	pending the results of testing or verification of the efficacy of treatment. • Mail screening • Passenger and baggage screening •		example for specified processing). • Pest / disease hotlines • Post-border diagnosis • Surveillance •
During transportation • Treatment • Maintenance of consignment integrity			

Prevention is the first and most cost-effective line of defence against invasive alien species (Wittenberg & Cock 2001). Prevention is considered the most economical, desirable, and effective management strategy against harmful invaders. Border inspection and exclusion programmes form the cornerstone of this. Effective control requires a high inspection capacity to enable inspection systems to cope with the ever-growing volume of goods, passengers and their baggage. Management of pathways represents the frontline in the prevention of biological invasions (Hulme, 2009). Exclusion methods that focus on pathways rather than individual species are more efficient and enable effort to be concentrated where pests are most likely to enter national boundaries. It also enables coverage of more species, more vectors and pathway systems, and underlying introduction mechanisms (Wittenberg & Cock, 2001).

2.4.1. Health inspection

Standards for the Health sector are set under the WHO's International Health Regulations as revised in 2005. The IHRs require member states to maintain sanitary standards at international borders and all points of entry including airports, sea ports and over ground crossings (WHO, 2016).

2.4.1.1. Vector free zones

The 2005 IHRs stipulate establishment of vector-free zones (VFZs) at seaports, airports, and ground crossings as well as within a 400 metre perimeter around these entry points. These can be achieved through regular active surveillance and vector control with a view to preventing or minimising transmission of risk pathogens with vectors/reservoirs. A second objective is to minimise chances of dispersal of local vectors to other countries through all modes of transportation. Routine surveillance and control programmes thus seek to achieve **zero levels** of exotic vector populations by denying breeding opportunities as far as possible and taking timely and appropriate control action in order to stamp out exotic species (WHO, 2016). The same is also true for native species. This is because it is recognized that whilst the presence of a small number of invaders may initially not pause a serious health risk, in the long term, there is potential for a few cases to spiral into an outbreakor epidemic/pandemic (WHO, 2016).

2.4.1.2. Core capacities required at designated ports of entry

The IHRs require the following core capacities at designated airports, ports and ground crossings:

- Appropriate medical service including diagnostic facilities to allow prompt assessment and care of ill travellers,
- Adequate staff, equipment and premises;
- Equipment and personnel for the transport of ill travellers to appropriate medical facilities;
- Trained personnel for the inspection of conveyances;
- Capacity to ensure a safe environment for travellers using point of entry facilities, including potable water supplies, eating establishments, flight catering facilities, public washroom and related solid and liquid waste disposal services and other potential risk areas,
- Capacities required to implement a programme and trained personnel for the control of vectors and reservoirs in and near points of entry (i.e. VFZs as previously described).
- Capacities for responding to events that may constitute a public health emergency of international concern,
- Provision of assessment of and care for affected travellers or animals by establishing arrangements with local medical and veterinary facilities for their isolation, treatment and other support services,
- Provision of appropriate space, separate from other travellers, to interview suspect or affected persons;
- Provision for the assessment and, if required, quarantine of suspect travellers, preferably in facilities away from the point of entry;
- Capacities to apply recommended measures to disinsect, derat, disinfect, decontaminate or otherwise treat baggage, cargo, containers, conveyances,

goods or postal parcels including, when appropriate, at locations specially designated and equipped for this purpose

- Capacities to apply entry or exit controls for arriving and departing travellers;
- Provision of access to specially designated equipment, and to trained personnel with appropriate personal protection, for transfer of travellers who may carry infection or contamination.

Effective personal protective equipment to be available at all times as shown in Table 10.

Table 10: Protective Clothing required for vector surveillance and monitoring

ITEM	FUNCTION
Disposable overall: They should be made of cotton. Specifications of weight and thickness are determined based on prevalent climatic conditions	Protects entire body especially the skin from exposure to droplets of insecticides
Reusable overall: Specifications of weight and thickness are determined based on prevalent climatic conditions.	Multiple use; protects skin from exposure to droplets. It must be washed separately before reuse
Broad-brimmed hat or helmet	Protects head and face from droplets
Face shield or goggles	Protects eyes from droplets
Respirator fitted with pre-filter: Filters in masks must be replaced each day for spray operators. For 8-hour filter masks, the mask itself should be changed once every two days.	Protects nose and mouth from airborne particles and prevents inhalation. Also protects against fine droplets and fume inhalation
Gas mask	
Protective gloves: They must be of the right size to fit each member of staff. Extras must be available in case of loss/ damage	Protect hands. Sleeves are always to be inside gloves. Gloves must be washed daily inside and outside. Damaged gloves must be discarded.
Boots: They must be of the right size to fit each member of staff. Extras must be provided for.	Protect feet. Overalls to be outside of boots
Raincoat	Protects body from rain during spraying

2.4.1.3. Health inspection objectives and procedures

The objectives of health inspection at points of entry include:

- To ensure compliance with legislation related to imported food and animal feed to protect food safety and animal health,
- To protect and enhance the public health by screening passengers for communicable diseases and ensuring their timely treatment thus preventing spread.

Health inspectors at ports of entry may be required to:

- Review manifests and routing of conveyances;
- Carry out inspections of baggage, cargo, containers, conveyances, goods, postal parcels or human remains ensure they are free from infection or contamination, including vectors and reservoirs;
- Implement treatment of the baggage, cargo, containers, conveyances, goods, postal parcels or human remains to remove infection or contamination, including vectors and reservoirs;
- Implement isolation or quarantine.

2.4.1.4. Passenger screening

International airports with many connections in particular, can be ports of entry for infectious diseases and are thus of special interest for public health authorities. WHO suggests that screening for communicable diseases can potentially reduce opportunities for transmission and forestall or delay international spread and in this regard suggests screening of arriving and departing travellers at international airports (Airports Council International, 2009; Gaber *et al*., 2009). A number of measures for identification and prevention can be used to minimise the risks of spread of communicable diseases. These include:

- **Exist screening:** Exit screening can be implemented to prevent contagious passengers from departing. This strategy was attempted during the initial outbreak of SARS (Gaber *et al.,* 2009). Passengers are screened before they board planes. This presents the opportunity to **encourage** ill passengers not to travel thus minimising chances of exposing other passengers and spreading disease.
- **Travel restrictions for infected passengers:** In addition to being near impossible to enforce because of political and economic reasons, mathematical models show that travel restrictions have a limited effect on the spread of infectious disease (Gaber *et al.,* 2009).
- **Entry screening:** Passengers can be screened on entry. Screening can be done through a number of methods. Selvey *et al*., (2015) identify the following:
  - Visual inspection of travellers, and/or
  - Fever screening of travellers using infrared thermal image scanners (ITISs).
- **Airline/ transit agency notification to health authorities of sick passengers and their contacts**: In many cases, if a flight attendant falls ill, all passengers are considered contacts. If a passenger falls ill, other passengers in their vicinity and flight

attendants who may have come into contact with them are considered contacts. Pilots are required to communicate such information to airport authorities on landing.

- Self-identification by means of health declaration cards.

Symptoms that may indicate the presence of a potentially contagious disease in a patient/sick passenger/crew member include:

- Fever,
- Severe headache,
- Abnormal sweating,
- Rapid breathing,
- Chest pain (shortness of breath) and excessive coughing,
- Severe vomiting,
- Diarrhoea and/or bleeding.
- Temperature above 38°C combined with one or more of the following:
    a) Diarrhoea and/or vomiting
    b) Rash or skin lesions
    c) Fever (high temperature shivering, rigor), and,
    d) Severe headache with alteration in consciousness and/or fits.

Public Health authorities are required to notify WHO of any potential international public health emergencies as outlined in the scheme illustrated in Annex III. Equipment requirements for vector surveillance are shown in Annex IV.

2.4.1.5. Balancing public health concerns with efficiency of international traffic and trade

Signatories to the 2005 IHRs agreed collectively to mitigate the spread of infectious diseases in a manner that would avoid "**unnecessary interference with international traffic and trade".** This then requires national authorities to be able to distinguish interventions with "reasonable" public health returns from those that should be considered unnecessary because they are minimally effective and excessively disruptive to traffic and trade (Khan *et al.,* 2013). They suggest the framework shown in Figure 9 to guide decision making.

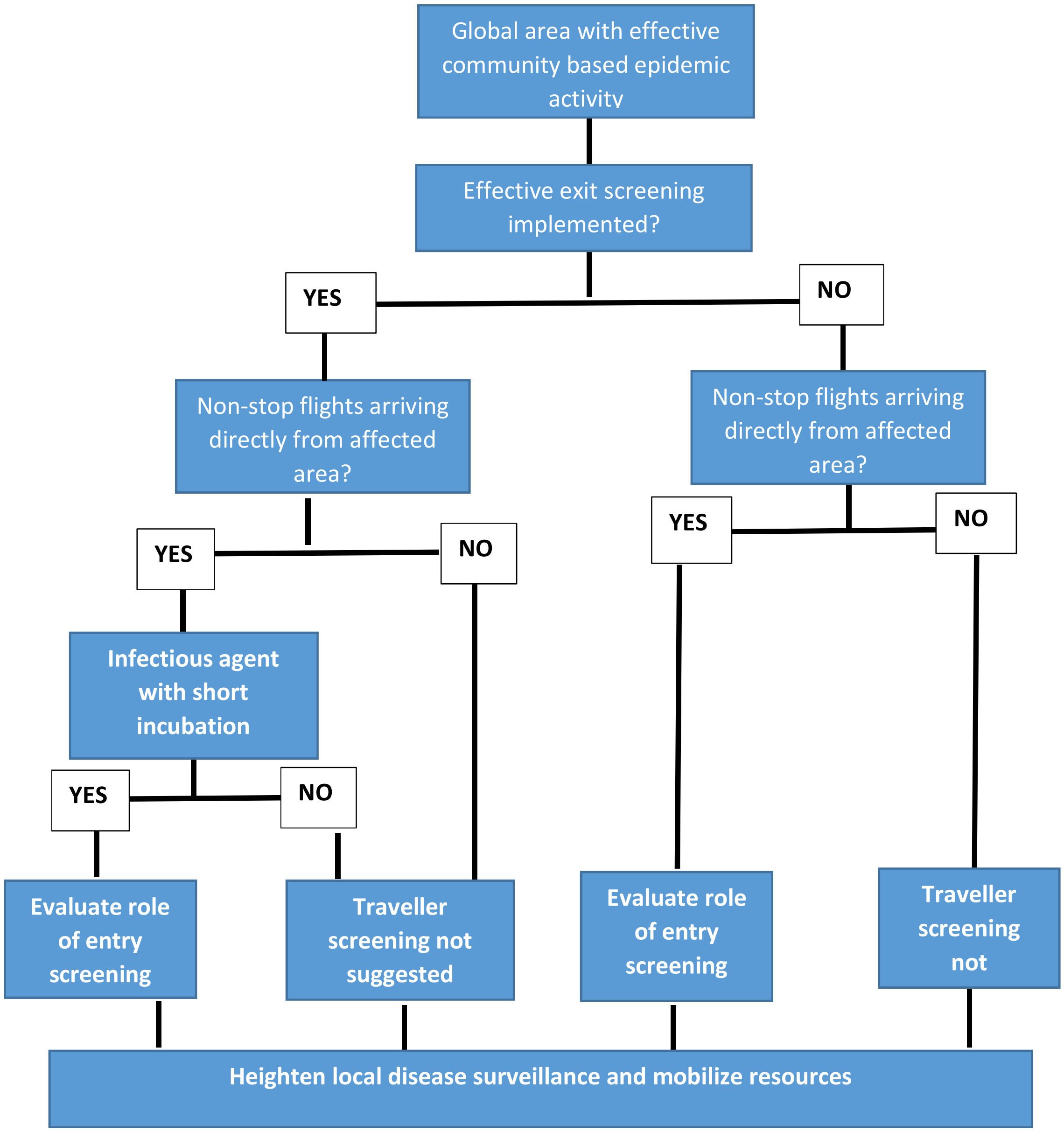

Figure 9: Risk-based traveller inspection

2.4.2. Phytosanitary Inspection

Inspection of consignments leaving and entering countries is a prerequisite in the management of pests and risks and is also the most widely used phytosanitary procedure worldwide (EPPO, 2006). Inspection involves checking introduced plants and animals for pests and diseases **prior to or on arrival at port of entry customs** (Wittenberg & Cox, 2001). PoE inspection involves close cooperation between Customs, Immigration and Quarantine officials to ensure that the risk of people, goods and cargo bringing in IAS into the country is reduced.

2.4.2.1. Phytosanitary inspection objectives

An export inspection is used to ensure that the consignment meets the phytosanitary import requirements of the importing country **at the time of inspection** and may result in the issue of a phytosanitary certificate. In the case of imports, inspection is carried out to verify the compliance of the consignment with the appropriate phytosanitary requirements (IPPC Secretariat, 2005). At import, inspection is carried out to ensure that consignments comply with phytosanitary import requirements. It is also carried out to detect organisms that may pause a risk to biodiversity, economy and human health. Assumptions underlying inspection as outlined in the Guidelines are:

- The pests of concern, or the signs or symptoms they cause, are visually detectable.
- Inspection is operationally practical, and,
- Some probability of pests being undetected is recognized.

Inspectors may be required to inspect consignments for:

- Compliance with specified import/export requirements: This includes: treatment, degree of processing, freedom from contaminants, whether the material is the required growth stage, variety, colour, age, degree of maturity etc. Other factors include absence of unauthorized plants, plant products or other regulated articles, packaging of the consignment, origin of consignment/lots and point of entry.
- Specified regulated pests, and;
- Organisms for which the phytosanitary risk has not yet been determined (IPPC Secretariat, 2005).

2.4.2.2. Steps in phytosanitary inspection

Phytosanitary inspection involves three broad steps i.e.

Step 1: Examination of documents

Documents accompanying consignments must be complete, consistent, accurate and valid. The main type of documents associated with import or export certification is the phytosanitary certificate. Phytosanitary certificates are issued to indicate that consignments of plants, plant products or other regulated articles meet specified phytosanitary import requirements and are in conformity with the certifying statement of the appropriate model certificate (IPPC Secretariat, 2001). They should be required by importing countries only for regulated products e.g. plants, bulbs and tubers, or seeds for propagation, fruits and vegetables, cut flowers and branches, grain, and growing medium. For processed products, they should only be required where the products by their nature or that of their processing, have a potential for introducing regulated pests (e.g. wood, cotton). They may also be required, for empty containers, vehicles, and organisms.

Step 2: Verification of consignment identity

The consignment must be accurately described by the accompanying documentation. The inspector must carry out an identity check to verify that the type or species of plant or plant product contained is in accordance with the phytosanitary certificate received or to be issued. The inspector may need to conduct a physical examination of the consignment to confirm the identity and integrity, including checking for seals, safety conditions and other relevant physical aspects of the shipment that may be of phytosanitary concern. Canada's Food Inspection Agency requires the following as a minimum for information requirements:

- Location of the consignment,
- Description of product including any required scientific or common names of the plant or plant product to be inspected,
- Size of the consignment,
- Type of consignment (i.e. commercial or non-commercial),
- Status of consignment (i.e. pre-cleared, imported for use in Canada, in-transit or being returned to Canada),
- Origin of the plant or plant product (i.e. where it was grown or harvested),
- Destination (e.g. some regions may have different import requirements for a commodity) and/or,
- End use.

Step 3: Inspection of the sample

The consignment is then inspected for symptoms that indicate the presence of disease, pest infestation or contamination. Signs to look for are shown in Table 11.

Table 11: Symptoms of infection in plants

Symptom	Description
Blight	Rapid and complete chlorosis, browning then death of plant tissues such as leaves, branches, twigs, or floral organs in response to infection by a pathogenic organism
Cankers	Necrotic, often sunken lesions that can be found on stems, branches or twigs. They usually result in a shrinking and dying of tissue which later cracks open to expose the wood underneath.
Chlorosis	Leaves produce insufficient chlorophyll, causing them to be pale green, yellow, or yellow-white
Dieback	Progressive death of shoots, branches and roots generally starting at the growing tip.
Discolouration	Changes in colour of leaves, stems or floral parts; can be either darker or lighter in colour than normal tissue.
Galls	Localized swellings or outgrowths of tissue caused by several types of plant pests that may be observed on any part of the plant.
Necrosis	Premature death of cells and living tissue due to damage cause by disease organisms or insects.
Powdery Mildew	White or greyish patches or spots generally found on succulent tissue. These are due to a fungus infection.
Pustules	Swellings on lead or stem surfaces; usually filled with spores.
Rots	Large necrotic areas in plant tissues
Rust	Discoloration or swellings on branches or trunks of conifers, leaf spots or streaking of plant tissue, for example, may be observed
Scorch	Brown discolouration on the leaves of plants caused by heat, lack of water or by fungi
Spots	Small, discoloured areas on tissue surfaces
Wilting	Refers to the Drooping of non-woody parts of plants due to low water availability to the cells. This can be due to soil conditions or to bacteria or fungi that clog the plant's vascular system.

From Canadian Food Inspection Agency (see http://www.inspection.gc.ca/plants/imports)

Inspectors must also look for signs of insect infestation. These include:

- Feeding damage,
- Plant discoloration,
- Wilting,
- Insect droppings (frass),
- Webbing,
- Tents,
- Swelling,
- Galls,
- Root nodules,
- Exit holes,
- Chewing, notching, mining and girdling of stems.
- Exoskeleton casts,

Egg masses, larvae and pupae may also be observed. Evidence of contaminants such as soil is also a consideration. The packaging material itself needs to be inspected for signs of insects etc.

2.4.2.3. Guidelines for preventing spread of pests during inspection

It is important that precautions are taken to prevent or minimize the potential spread of pests during inspection. This applies to both commercial consignments as well as passenger goods, mail etc. The following guidelines can be used to minimise this risk.

- Establish an inspection area that promotes containment of the plant material,
- Keep doors closed when possible to reduce the potential movement of pests,
- Minimize the entry of personnel into the inspection area,
- Treat all material as if it was infested or infected,
- Use good housekeeping practices to keep the work area neat and clean (e.g. clean up spilled soil and growing media),
- Ensure the proper removal, containment and destruction of infested or infected material/consignments, and.
- Complete all paperwork outside the inspection area if this activity presents a risk of disseminating pests if carried out at inspection site (see http://www.inspection.gc.ca/plants/imports)

2.4.2.4. Inspection equipment

Suggestions for phytosanitary inspection equipment are shown in Table 12.

Table 12: Equipment for phytosanitary inspection

Category	Item
Personal protective equipment	• Gloves • Safety vest or other high-visibility clothing • Boots • Ear protection (earmuffs and earplugs) • Eye protection (safety goggles); • Disposable face mask, • Respirator mask or gas mask • Hard hat or helmet
Inspection tools and instruments	• Buckets and tins: Useful for collecting samples of loose commodities (e.g. seeds, grain, woodchips). • Augers and triers, • Trays, sieves and pans, • White paper • Magnifying instruments: o Hand-held magnifying lens o Magnifying glass,

	○ Lamp and microscope
Pest extraction equipment	• Forceps • Small paintbrushes, • Scissors, • Knives, • Probes, • Scraping tools, • Hammer, • Mallet, • Chisel and inspection kit
Specimen collection equipment	• Pest specimen bottles, • Sample tubes/ vials • Liquid preservative, • Plastic bags, • Labels and pencils, • Sealing tape and, • Specimen storage boxes.

(From Department of Agriculture 2013)

See http://www.agriculture.gov.au/export/controlled-goods/plants-plant-products/plantexportsmanual/volume-9/volume-9-part-2

2.4.2.5. Prioritization and enhancing efficiency of Inspection Services

ISPM No. 29 "Recognition of Pest Free Areas and Areas of Low Pest Prevalence (IPPC Secretariat, 2007) sets out the guidelines for international cooperation in recognition of Pest Free Areas (PFAs) and Areas of Low Pest Prevalence (ALPP). Another strategy is to pre-clear goods at ports of export and where necessary treat goods and their packaging to ensure they are pest and disease free (Wittenberg & Cox, 2001).

2.4.2.6. Risk-based inspection

Inspectors at points of entry must find a way of prioritizing in order to direct effort and resources to higher risk areas. Decision-making on when to use inspection must take into a count a number of factors. ISPM 23 includes the following in addition to the regulatory requirements of the importing country and the pests of concern**:**

- Any mitigation measures that have been applied in the country of export,
- Whether inspection will be implemented on its own or along with other measures,
- The type of commodity and its intended use,
- The place and area of production,
- The size and consignment configuration,
- The volume, frequency and timing of shipments,

- Past experience with experience with origin/shipper,
- Means of conveyance and packaging,
- Available financial and technical resources (including pest diagnostic capabilities),
- Previous handling and processing,
- Sampling design characteristics necessary to achieve the inspection objectives ,
- The difficulty of pest detection on a specific commodity,
- The experience and the results of previous inspections, and
- The perishability of the commodity.

Annex V shows a flowchart to guide decision-making.

Risk based inspection refers to an approach that focuses available resources to higher priority areas thus enabling attainment of better results (in this case reducing the number of infested shipments that enter the country) without increasing costs. Under risk-based inspection more inspection effort is spent on higher risk consignments than on medium or low risk shipments. Risk-based inspection is especially important because the rate of growth in volume of goods traded internationally has not been matched by the growth in budgetary allocations to quarantine inspection (Lindsay *et al*., 2016).

The Animal and Plant Health Inspection Service (APHIS) of the United States has recently moved from a uniform 2% inspection of every consignment of propagative plant material to a risk-based approach that pays more attention to higher risk material. APHIS established a Propagative Monitoring and Release Program (PMRP) based on analysis of pest interception histories for specific country/ commodity combinations. The 25 country/commodity combinations that qualify for PMRP (see www.aphis.usda.gov/import_export/plants/plant_imports/pmrp.shtml) are inspected using risk-based sampling to confirm their continued eligibility for the programme. Under the new protocol, APHIS categorizes shipments of imports of plants and plant materials based on the potential level of risk for the introduction of invasive pests and diseases. More samples of higher risk shipments are selected for sampling and inspection as shown in Figure10. This means reduced waiting times for material that is listed in PMRP but it may also mean longer waiting times for higher risk material (APHIS, 2012).

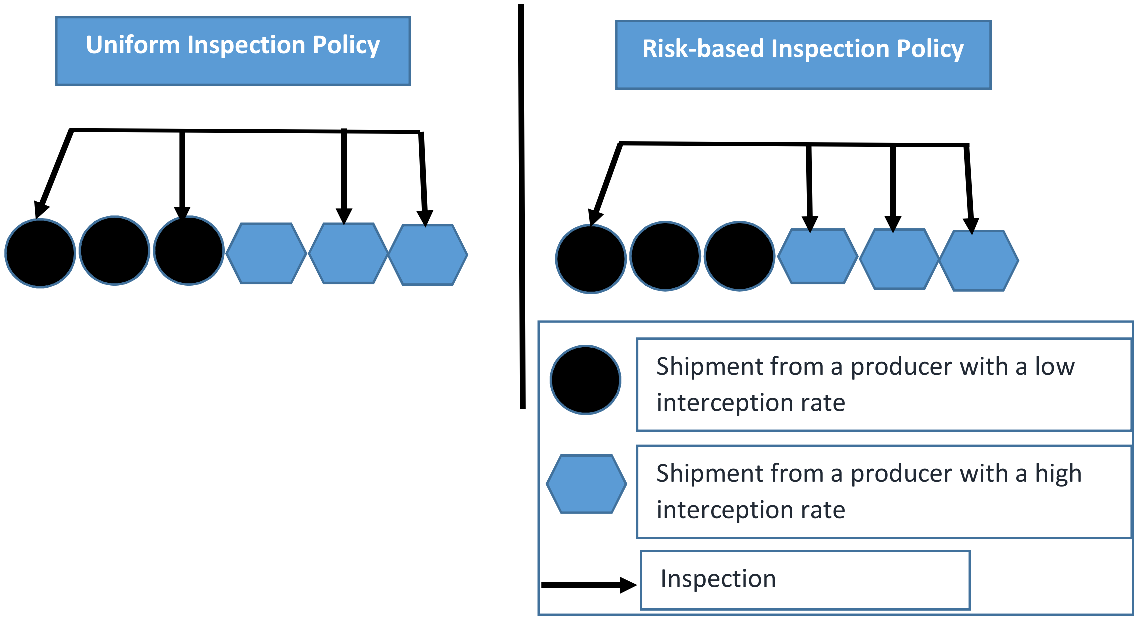

Figure 10: Uniform vs Risk--based inspection

(From Epanchin-Niell *et al*., 2016)

2.4.3. Animal Health Inspection

The OIE has developed some guidance documents for animal health i.e. the Terrestrial and Aquatic Animal Health Codes respectively.

2.4.3.1. Terrestrial animals

The Terrestrial Animal Health Code stipulates that prevention strategies should be applied at several levels. These include:

- Import quarantine programmes;
- International border security;
- Quarantine procedures at international airports, seaports and mail exchanges;
- Disease prevention strategies at the national and local level; intelligence-gathering;
- Cross-border and regional cooperation; and,
- On-farm disease biosecurity (OIE, 2016[1]).

As with other sectors, border inspection of live animals, products of animal origin and certain feeding stuffs, on any other means that might have the capability to carry an agent of animal diseases and any other health risks to humans or animals is a key pillar in the prevention of introduction of possible health risks into a country. Veterinary border control is a key factor to ensure that live animals and products of animal origin entering a country are safe and meet the specific import/transit conditions laid down by legislation within the country concerned.

Because they can transmit serious human and animal diseases or carry other risks, imported live animals and products of animal origin present the highest level of risks. They must of necessity therefor be subjected to specific controls at the point of entry. A consignment of live animals or products of animal origin should only enter a country if it has satisfactorily undergone the specific veterinary checks and a **'Veterinary Entry Document'** has been issued for release into free circulation (OIE, 2016[1])

2.4.3.2. Terrestrial animal Health Inspection objectives

Inspection is applied within the country and at the borders for the following purposes:

i. To assist in implementation of control and eradication programmes;
ii. To ensure compliance with official standards of animal health and quality of animal products for the purposes of internal and external trade.

The range of goods and items that must be searched include commercial cargo and non-commercial items such as passenger goods/ baggage, mail etc. (Meyer-Gerbaulet *et al.,* 2010).

2.4.3.3. Border posts and quarantine stations

Article 5.6.1.of the Terrestrial Animal Health Code places the following requirements for border posts and quarantine stations.

i. Adequate organization and sufficient equipment for the application of the measures recommended in the Code.
ii. Facilities for the feeding and watering of animals.

Article 5.6.2. further requires that where justified, and as determined by the amount of international trade and the epidemiological situation, border posts and quarantine stations should be provided with a veterinary service including personnel, equipment and premises for:

i. Carrying out clinical examinations and obtaining specimens of material for diagnostic purposes from live animals or carcasses of animals affected or suspected of being affected by epizootic diseases, and obtaining specimens of animal products suspected of contamination;
ii. Detecting and isolating animals affected by or suspected of being affected by an epizootic disease;
iii. Carrying out disinfection and possibly disinfestation of vehicles used to transport animals and animal products.

Another requirement is for each port and international airport to be equipped for the sterilisation or incineration of swill or any other material dangerous to animal health.

2.4.3.4. Aquatic animals

Concerns with imports of aquatic animals

The Aquatic Health Animal Code lists a number of fish diseases as concerns for TBM. These are:

- Epizootic haematopoietic necrosis disease
- *Aphanomycesinvadans* (epizootic ulcerative syndrome)
- *Gyrodactylus salaris*
- Highly Polymorphic Region (HPR) Infectious Salmon Anaemia Virus (ISAV) -deleted or Non-deleted Polymorphic Region (HPR0) infectious salmon anaemia virus
- Salmonid alphavirus
- Haematopoietic necrosis
- Koi herpes virus
- Red sea bream iridoviral disease
- Spring viraemia of carp
- Viral haemorrhagic septicaemia

2.4.3.5. Criteria for acceptance of aquatic animals and their products

Article 5.4.1. of the Aquatic Animal Health Code provides that only aquatic animals/ aquatic animal products that meet the following criteria should be considered for trade:

- The aquatic animal, its tissues or aquatic animal product must be free of pathogenic agents,
- The water (including ice) used to process or transport the aquatic animal or aquatic animal product is not contaminated with the pathogenic agent or;
- The pathogenic agent can be inactivated by treatment and or processing and the processing prevents cross contamination of the aquatic animal or aquatic animal product to be traded.

The treatment and processing methods used must comply with the following:

- Use standardised protocols and include the steps considered critical in the inactivation of the pathogenic agent of concern. These may include:
    - Physical methods (e.g. temperature, drying, smoking) and/or
    - Chemical (e.g. iodine, pH, salt, smoke); and/or
    - Biological methods (e.g. fermentation).
- Be conducted in accordance with Good Manufacturing Practices (GMP) and;

- Any other steps in the treatment, processing and subsequent handling of the aquatic animal product do not jeopardise the safety of the traded aquatic animal product.

2.4.3.6. Pre-border measures applicable to aquatic animals and their products

- Exports of live aquatic animals and aquatic animal products should only be authorised subject to correct identification and inspection;
- Where required by the importing country, the aquatic animals can be subjected to certain biological tests or to prophylactic parasitological procedures within limits of a defined period of time before their departure;
- The aquatic animals should be subjected to observation prior to departure from the country of export either in the facility they are reared, or at the frontier post. If confirmed clinically healthy and free from listed diseases or any other specified infectious disease by a designated official, the aquatic animals should be transported to the place of shipment in specially constructed containers, previously cleansed and disinfected, without delay and without coming into contact with other susceptible aquatic animals.
- Transportation of aquatic animals for breeding, rearing or slaughter should be carried out directly from the establishment of origin to the place of shipment or to the processing establishment in conformity with the conditions agreed between the importing and exporting countries.
- Exports of live aquatic animals or eggs or gametes destined for a country/ zone or aquaculture establishment officially declared free from one or more of the listed diseases.
- The aquatic animals/animal products must be accompanied by an international aquatic animal health certificate conforming to the models approved by the OIE.
- In the event that an outbreak occurs in the facility/ natural water from which live aquatic animals have been exported, the exporting country must inform the competent authority in the country of import and any country (ies) of transit if there is a chance that the exported consignmentis infected (OIE, 2016[2]).

2.4.3.7. Other measures

These are mostly dependent on effective inspection, certification and compliance regime of the exporting country. Efficiency is enhanced through cooperation between Competent Authorities of the importing and exporting countries. Measures include:

- **Certification of production source**: The inspection, testing and certification of hatcheries and other aquaculture production facilities as free from specific pathogens,

- Use of specific pathogen free (SPF) stocks e.g. SPF stocks for some species of penaeid shrimp (SPF *Litopenaeus vannamei*, *L. tylirostris* and *Penaeus monodon* are currently available). However, there is no universally accepted standard (e.g. type, number and frequency of diagnostic testing that must be performed) as to the criteria that must be met for a production facility to achieve SPF production status.
- **Zoning i.e.** Sourcing stock from production facilities located in disease-free zones (Arthur *et al.,* 2008).

2.4.3.8. Measures Applicable at the border

Article 5.9.1. of the Aquatic Animal Health Code provides that:

- Live imports should only be accepted subject to an international aquatic animal health certificate issued by a member of the personnel of the Aquatic Animal Health Service of the exporting country.
- The country of import may require advance notice regarding the proposed date of entry into its territory of aquatic animals with specification of the species, means of transportation and the frontier post.

The country of import is also required to publish a list of frontier posts that are equipped for conducting control operations at importation and enabling the importation and transit procedures to be carried out in the most speedy and efficacious way (OIE, 2016[2]).

2.4.4. Living Modified Organisms

In the context of management of the risks associated with LMOs, inspection (and monitoring) can be implemented at various points along the development, transport, handling and use of the LMO. The aim of inspection and monitoring of /LMOs is to verify compliance with the conditions of authorization associated with that particular activity. Examples of elements and reasons for inspection are shown in Table 13.

Table 13: Examples of elements that may be inspected and reasons for inspection

Element inspected	**Reason for inspection**
PoE	To ensure compliance with import requirements
Contained use facilities such as research laboratories, greenhouses etc.	Inspection is carried out to ensure that facilities are adequate for the level of risk posed by the LMO concerned, and are also in compliance with the requirements for the specific containment use as per the authorization.
Research related documents	To ensure data integrity and quality requirements are met

Means of transportation	To ensure compliance with conditions for transportation as provided for under the national biosafety framework
Storage and handling facilities	To ensure compliance with measures under which permit was issued
Confined field trials	To ensure compliance with risk management measures under which the permit was issued
General field releases	To ensure compliance with risk management measures under which the general release permit was issued

Based on Bhutan Agriculture and Food Regulatory Authority (2014)

2.4.4.1. Inspection of LMOs at Points of Entry

It is not possible to visually distinguish between an LMO and a non-modified organism. The role of border inspection in the context of LMOs is to ensure that the status of the consignment complies with the conditions specified with respect to national biosafety regulations. The CPB recognizes a range of applications and uses of LMOs including:

- Contained use
- General release
- LMOs destined for use as Food, Feed and Processing (LMO-FFPs)
- LMOs for Pharmaceutical use etc.

The National regulatory framework will then stipulate how these categories will be approved and the conditions for their approval. With regards to LMO-FFPs, the requirement may be:

- **Non-GM/ GM-free:** In this case the country of import may want to satisfy herself that the consignment is indeed GM free or, if GM material is present, it is within the country's acceptable level for accidental/inadvertent mixing. Cameroon however has not elaborated a threshold level for inadvertent presence of GM material. Further, two types of inadvertent mixing are recognised:
    - **Low level presence:** Low level presence (LLP) refers to detection of low levels of GM crops that have been approved in at least one country on the basis of a food safety assessment.
    - **Adventitious presence:** Adventitious presence (AP) in commodities is defined as detection of the unintentional presence of GM crops that have not been approved in any countries on the basis of a food safety assessment (FAO, 2014).

The Biosafety Competent Authority may want to satisfy herself of the status of the LMO with regards to these categories. The Inspector must then first conduct a document verification check. The Inspector may then proceed to draw a sample initially for testing in the field e.g.

using a trait test kit. A trait test kit is an immunoassay-based test that provides a check for presence of GM material. The test is trait specific and will not provide any further information about the identity and quantity of the GM material. A sample may then be collected to be further analysed in a designated GM detection laboratory.

An example of an LMO inspection is shown in Figure 11. The process begins with receipt of an inspection application.

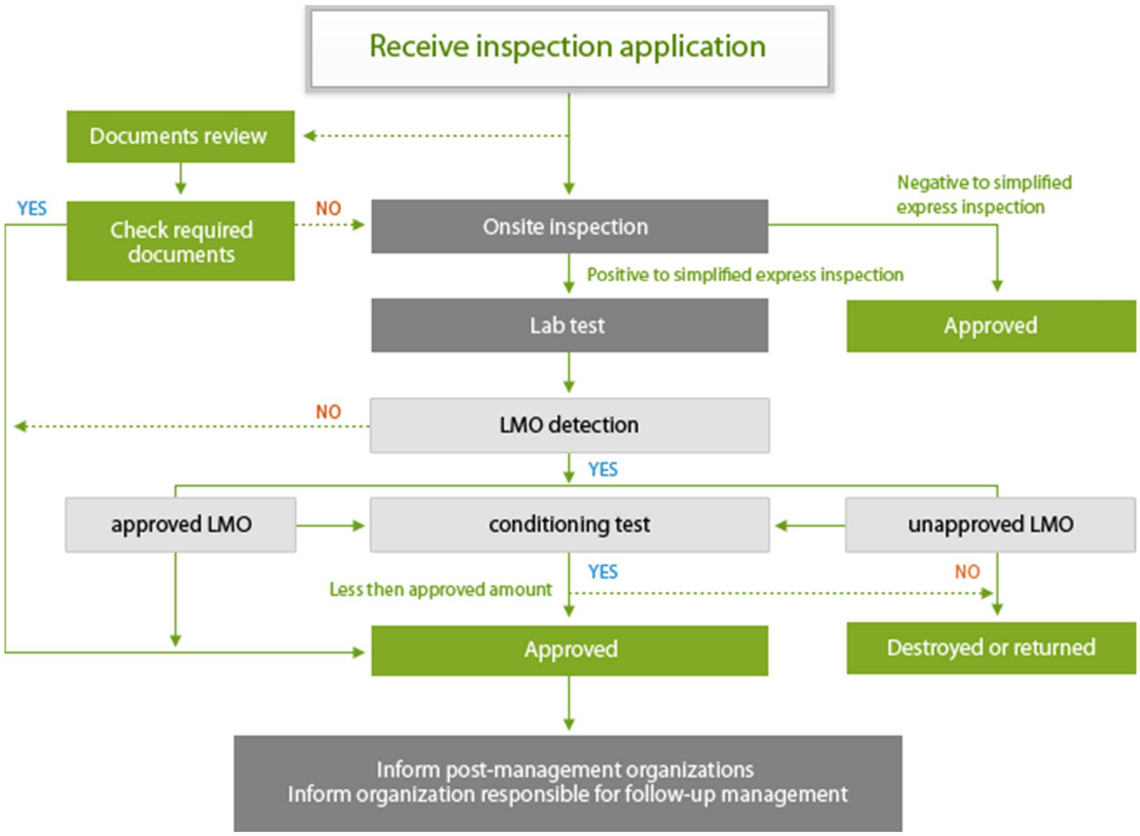

Figure 11: LMO inspection process Korea

See http://www.qia.go.kr/english/html/Plant/Plant_011-15.jsp

2.4.4.2. LMO Detection Methods

LMO/GMO detection methods are based on basic principles in rDNA technology. Genetic manipulation in modern biotechnology involves insertion of foreign into organisms. Genes code for proteins which in turn determine the attributes of organisms. LMO detection methods thus either test for:

- **Analysis of proteins, or,**
- **Analysis of DNA.**

Based on these broad categories, three methods of GMO detection exist. Two of these are protein-based and the last is DNA-based.

A. **Protein-based methods/ Immuno-analysis:** These methods focus on the protein product associated with the introduced gene. Two methods currently exist. These are the Strip-test (Lateral Flow Device/ Dipstick) and the Enzyme Linked Immunosorbent Assay (ELISA).
    i. **The Strip test (Lateral Flow Device / Dipstick):** This is a rapid immuno-assay based method for detecting presence of protein coded by transgenes. It is used for unprocessed material including seed, grain or leaves. The basis of the detection is immobilised antibodies that are specific to GMO proteins. The antibodies are bound on a strip. In the presence of the specific GM protein, a reaction occurs. This method is suited for qualitative or semi-quantitative testing.
    ii. **ELISA:** This method is also antibody-based. In this case the GMO-protein specific antibody is immobilised in a multi-well solid plate. The method is useful for both qualitative and quantitative analysis of seed, leaf and grain material. It requires a laboratory and is more time intensive than the lateral flow test.

B. **Direct DNA Analysis**

    DNA analysis uses molecular techniques to detect the inserted transgenic DNA in a sample using the Polymerase Chain Reaction (PCR). The PCR enables amplification of DNA within a relatively short amount of time. Potentially, millions of copies of a small amount of DNA can be generated from very little starting material within a short amount of time. Primers that are specific to the transgene construct are used to amplify the DNA (see http://www.gmotesting.com/Testing-Options/Genetic-analysis).

2.4.5. Inspection of Means of Transportation

2.4.5.1. Inspection of cargo holds in planes and ships

Cargo holds in planes and ships represent huge open spaces that are used throughout the life span of the craft or vessel to transport large shipments between points often across the world. The relative pest risk potential of a plane or ship is related to the history of where it has been combined with what it has transported. Inspectors need to be aware of the risk that cargo holds pause and respond accordingly. Examples of potential risks include insect pests, seeds of weeds etc. Other items of concern include used auto parts, solid wood packaging etc.

Where concerns arise, it may be necessary to fumigate cargo holds (Westbrooks *et al*., undated).

2.4.5.2. Ship storerooms and garbage containers

Examples of prohibited pests that may be found in ship storerooms and garbage containers include fruit flies and snails on produce and discarded materials, meat from countries that may be infected with animal diseases etc. Inspectors must also be aware of these risks and how to respond to them (Westbrooks *et al*., undated).

2.4.5.3. Vehicles and railway cars

Inspectors must be aware of hidden compartments such as car doors and carburettors which can be used to stash prohibited materials. Vehicles also present risks of hitchhiker species that may be trapped e.g. on wheels & tyres, under hoods etc. Some countries have developed manuals for inspection and cleaning of craft and vehicles at airports, sea ports and overland borders.

2.4.6. Inspection of passengers and baggage

Inspection of passengers and their goods contributes to biosecurity through prevention of entry of IAS and introduced plant and animal pests and diseases which can be a serious threat to biodiversity, agriculture, livestock and even human health. Border inspection of passengers should be carried out at all points of entry including airports, sea ports and overland borders covering all modes of transportation i.e. airplane, ships and other vessels, trucks, cars, buses etc. Examples of biosecurity risks associated with passengers include:

- Fruit and vegetables may harbour invasive diseases and/ or pests e.g. citrus canker and Mediterranean fruit fly in oranges,
- Sausages and other meat products from many countries can contain animal disease organisms that remain viable for many months and even survive processing,
- Meat scraps from meals on foreign ships and airplanes could contaminate domestic livestock feed sources if not properly disposed of.
- FMD can be transmitted on footwear or clothing if passengers passed through FMD-affected areas.

Risk profile of travellers in Cameroon

Although the Biosecurity Profile Study carried out under the CBP did not obtain data on the international movement of people through Cameroon's airports and land borders, it noted that travellers entering Cameroon pose some biosecurity risks as they can bring in pets, seeds, plants and animal products that are not available in the country (MINEPDED, 2015[2]).

Increasingly, passengers and their goods are being subjected to inspection in an effort to address the ever growing threat of IAS. The sheer volume of passengers and the goods they bring into countries is placing a strain on already resource strained inspectorates. At the same time, passengers must not be subjected to unnecessary delays in ports of entry. This then requires inspectors to balance the biosecurity needs with resource allocation and respect for international agreements and norms with regards to facilitating smooth travel.

The United States' Passenger inspection programme utilises a uniform process at all points of entry as follows:

- Passengers are required to complete baggage declaration forms,
- Inspectors also question passengers to ascertain where they have come from and what agricultural products they are carrying.
- By combining this information, inspectors can judge the likelihood that a particular passenger may be carrying regulated goods.
- Inspector dog teams (the "beagle brigade") roam the baggage arrival areas to sniff out agricultural products.
- All agricultural products are subject to inspection. Infested products are confiscated and/or prohibited from entry.
- Passenger baggage is also inspected randomly.
- The United States Department of Agriculture (USDA) also uses pre-entry clearance for passengers travelling from for example, Hawaii and Puerto Rico.

An example of a passenger inspection process is summarised shown in https://www.cbp.gov/sites/default/files/documents/agr_inspect_process_3.pdf

2.4.7. Methods for agricultural inspections

- **Visual inspection:** This involves the inspector physically opening luggage and inspecting it for illegal material.
- **Sniffer dogs:** Sniffer dogs have proved useful for detection of some alien species. The United States Customs & Border Protection Agency is increasingly recognizing dogs as a key tool in screening both passengers and cargo to prevent entry of harmful pests and pathogens into the US. Dogs are able to discriminate and target specific odours and are thus able to pick up the scent of an orange, snail, vegetables, plants, meat etc. hidden in luggage and cargo. Sniffer dogs are also used by border protection agencies in Australia, New Zealand, Canada and South Africa. Apart from detection of IAS, dogs can also help in detection of smuggled restricted species. Sniffer dogs have been reported to have been able to detect zebra mussels clinging onto boats with 100% accuracy in less than 3 minutes including play and reward time whilst humans were only reported to have been able to do so with 75% accuracy.

- **X-ray and related equipment:** X-rays and related equipment are often used for inspection of passenger luggage and baggage and have shown increasing usefulness in detection of material that has potential for invasiveness including fruit, seeds, animals etc. However not all border inspection points have installed them (Wittenberg *et al*., 2001). X-Rays and other Non-intrusive Inspection Systems have the benefit of being able to penetrate container to generate an image of its contents without the need to unload and dismantle it. This presents added advantages in the light of ever increasing volumes of goods being moved across borders. Carbon detecting machines where available are also useful for detecting IAS (Wittenberg *et al*., 2001).

- **Ruggedized Advanced Pathogen Identification Device** (RAPID) shown in Figure 12 is a handheld instrument that can identify pathogens in the field within 30 minutes instead of up to several days in the laboratory. RAPID is currently being tested for possible use at ports of entry. The RAPID allows for field identification of possibly dangerous pathogens quickly, safely, and accurately.

Figure 12: The RAPID

See http://www.copybook.com/companies/idaho-technology/articles/rapid-ruggedized-advanced-pathogen-identification-device

CASE 1: Avian Influenza (NH5)

This case revealed how the country dealt with a recent biological invader i.e. the avian influenza (NH5) which is listed in the country's national black list of invaders. The biological invasion was detected in one major region in the country (Centre Region). Urgent Measures (Ministerial Order no. 0008/MINEPIA/DSV of 26 May 2016) identified the Region where the zoonosis had erupted and instituted biosecurity measures to be taken. Initially at the Mvog-Betsi Government Poultry Centre, out of a population of 33000 birds/ chicken, a high mortality rate of 24000 (75%) was registered. The rest of the stock was immediately slaughtered and incinerated/buried.

The creation of a multi-sectoral Contingency Program for prevention and fight against avian influenza (N5) was put in place based on 5 strategic axes:

- Surveillance of the epidemiology;
- Prevention, containing and biosecurity;
- The response of health systems;
- Operational research;
- Sensitization and communication
- There was a call to the population for vigilance and to inform any suspected mortality cases to veterinary officials.

The Order carries three main types of measures which are:

i. Measures to be taken to protect poultry farms if no case is identified in your region (isolation and sanitary measures, control of circulation, management of the health of the stock);
ii. Measures to be taken when some cases are reported/identified in the region;
iii. Measures to be taken in case of high mortality on your farm.

In 2012, the United Nations Development Program (UNDP) in Cameroon and the Government of Cameroon had provided a donation of equipment including diagnostic kits for laboratory analysis which helped in facilitating analysis to be carried out in Cameroon instead of foreign countries like in the past.

The above measures combined were taken to control the establishment and spread to other regions of the virus and eradicate the invasion at the entry point where it occurred.

Various Inspection structures exist in the country under the Ministry of Livestock and Animal Industries. These carry out daily, weekly and monthly inspections aimed at diagnosing any emerging or re-emerging animal viruses.

The case study had as an intention to contextualize the challenges faced in prevention of biological invasions and to analyse whether the management approach used tied with the theoretical concepts found in all the available inspection manuals. In fact for the analysis to be complete, focus had to be paid also to the detection, diagnosis and monitoring of the invasion.

Case study #2: Ebola virus (Ebola fever)

Ebola fever was declared a public health level III Emergency by the Director of the World Health Organization in 2014. Several West African countries were already grappling with cases of the epidemic reported in their countries including neighbouring Nigeria where one case was registered at the Lagos International Airport. In August 2014, the Governor of the Littoral Region of Cameroon reacting to public rumours about the presence of the disease at the economic capital of Cameroon stated that only the Pasteur Centre had the capacity to detect the disease. Sensitization campaigns on the disease had mostly consisted in calling on the population to wash their hands, avoidance of consumption of bush meat, and avoidance of performing rituals with corpses. An example of the outreach material is shown below.

Surveillance of the entire Cameroonian territory due to its porous borders with Nigeria was strengthened.

The lead agencies involved were MINSANTE & MINEPIA: Other preventive measures put in place were:

- Flights between Ebola fever infested West African countries and Cameroon were prohibited,
- Thermal cameras were installed at the various ports of entry including thermoscope laser;
- Protective clothing was acquired and distributed to inspectors
- A communication strategy based on identification of target groups and development of specific messages for each was developed. Sensitization materials targeting each stakeholder group were prepared. These included fliers, communication through electronic (radio/Television) as well print media (Newspapers)
- Isolation centres and quarantine infrastructure were equally instituted,
- Green telephone numbers were provided/communicated to the public to signal any occurrence.
- Training of personnel and other support teams on techniques to be used;
- Analysis of the pathways of the virus,
- Analysis of the risk to Cameroon,
- Prevention measures were instituted at airports, seaports and land borders,
- Collaboration with other Ministries e.g. Livestock Ministry,
- Health inspectors deployed at ports of entry
- Enhancement of quarantine infrastructure at airports,
- Collection of statistics on travellers and follow up of suspected cases.
- Other measures as monitoring strategies include the trial of an Ebola vaccine on volunteers (which has been highly criticized by the public).

A sum of 630Million Francs (CFA) was needed to fight the Ebola invasion in Cameroon to prevent an epidemic. The Ebola virus had claimed over 11,000 lives in some West African countries.

CASE 3: Prevention and Control of Poliomyelitis in Cameroon

The WHO had as target in this 21st century to eradicate polio on the surface of the earth. Polio is a species of biological invasion whose pathway of introduction is from human to human especially through contaminated faecal infections. Faeces from an individual who has not been immunized can contaminate another individual. So many slogans had been used to sensitize governments and parents on the negative impacts of the disease and the actions to be taken to prevent it. Some of the slogans included "kick polio out of Africa". The government of Cameroon had placed polio as one of the major public health epidemics which had to be prevented, controlled and eradicated as the disease attacks young children at their early infancy and renders them handicapped through an infirmity of the lower limbs. Mass immunizations campaigns were instituted to prevent, control and eradicate poliomyelitis but sometimes, these campaigns encountered strong resistance from certain stakeholders notably because of religious and other socio-cultural beliefs. For some times, the government had already registered successes in the prevention of the invasion until 2014 when one new case of the wild type of polio was reported again from the northern part of Cameroon. It was imported from Nigeria by refugees escaping the *boko-haram* terrorist attacks.

People and goods move freely between the neighbouring countries of Cameroon due to the porous nature of the national borders. These countries (Nigeria, Chad, Central African Republic, Gabon and Equatorial Guinea) have their respective immunization strategies, so poor measures taken in one country in the field of the fight against polio can consequently affect another country. Several refugees moved from neighbouring Nigeria to Cameroon from the commencement of the terrorists' attacks of boko haram. It was during these conflicts that the lone case of polio re-surfaced in the Northern part of Cameroon (the wild species) as opposed to the domesticated species which had been prevented and eradicated in the past. It should be noted that just one occurrence of polio can endanger all the unvaccinated children in a country.

Strategies put in place by Cameroon Government to kick polio out of Africa:

- Border Monitoring ;
- Monitoring at Household levels, (door post demarcations), sensitizing mothers, priests, Imams, pastors, school teachers, traditional rulers; proximity campaigns within communities, health centres, markets, etc.
- Vast immunization campaign; (10 mass campaigns conducted in 2014; public awareness creation);
- Strengthened routine immunization,
- Communication to raise public awareness; radio, press, flyers, public speeches by senior officials;
- Training of field workers to ensure monitoring of the epidemic and immunization.

Challenges faced:

- Cross border immunization- since every government is sovereign, Cameroon government does not know whether the other neighbouring countries have also done a massive coverage of their own territory in the field of poliomyelitis immunization (so the danger is imminent and the need for high monitoring strategies implemented especially around the border communities);

- Risk factor of some parents hiding children from immunization due to unfounded beliefs;
- Children born out of hospitals and not followed up.

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- Children born out of hospitals and not followed up.

It should be noted that the strategy put in place did not include other Ministries like MINEPDED whereas the wild type of polio is found in the environment. The biosecurity program should therefore address these deficiencies/gaps.

Key Points

- Cameroon receives large volumes of fresh fruit and vegetables as imports. Whilst these are short-lived, they still pose some risk of entry of fruit flies.
- Other high risk pathways include imports of (dead) aquatic organisms, second hand vehicles and equipment,
- A range of biosecurity related international regulatory instruments have been negotiated and adopted. These include:
    - The International Health Regulations under WHO which are aimed at aimed at prevention, protection, control and provision of a health response to the international spread of diseases whilst minimising undue restrictions on international traffic and trade.
    - The Sanitary & Phytosanitary Agreement and the Technical Barriers to Trade under the WTO.
    - The Convention on Biological Diversity and its Cartagena Protocol on Biosafety
- International standard setting agencies have also developed a range of guidance e.g.
    - The International Plant Protection Convention,
    - The World Organization for Animal Health and its Terrestrial and Aquatic Animal Health Codes,
    - These provide guidance for regulating transboundary movements of plants/animals and controlling spread of diseases and pests.
- Cameroon has put in place regulatory measures to domesticate some of these instruments but among the challenges is a largely fragmented institutional set up.

End of Module revision and application questions

QUESTION 1

Name three standard setting bodies that are recognized by the World Trade Organization.

QUESTION 2

Name two agreements under the WTO and explain their implications for Cameroon.

QUESTION 3

Through what documents do Parties of the CBD elaborate their strategies for national implementation of the Convention?

QUESTION 4

Through which Article has the CBD drawn its programme of work on IAS?

QUESTION 5

Name the international instruments that is aimed at regulation of transboundary movement of Living Modified Organisms.

QUESTION 6

Which of the following is **NOT an international agreement?**

CBD UNCLOS IUCN

QUESTION 7

Explain what is meant by Vector Free Zones

QUESTION 8

Name five organisms that are targets of surveillance programmes in VFZs.

QUESTION 9

List five symptoms that may indicate that a passenger is infected with a communicable disease.

QUESTION 10

Name two documents that public health officials may be required to insect at ports of entry.

QUESTION11

Name the three stages in phytosanitary inspection.

QUESTION12

List five symptoms of plant disease that plant health inspectors need to examine consignments for.

QUESTION13

State any three factors that need to be considered as part of risk-based inspection.

QUESTION14

Name three methods that may be used to inspect consignments and passenger goods at ports of entry.

QUESTION15

Name three methods that can be used for GMO detection.

QUESTION16

List precautions that need to be taken in the event that a consignment of aquatic organisms is found to be infected on entry during inspection.

3. MODULE III: RISK ANALYSIS

Purpose: To enhance the understanding of risk assessment principles and practice as well as how they are applied in biosecurity.

Format: PowerPoint Presentations, Group discussion and Group activities.

Expected outcomes: By the end of the session, trainees will be able to:

- List and explain the components of risk analysis
- Explain considerations for application of risk management for various groups of organisms,
- Explain risk management options for management of various categories of invasive organisms including their feasibility, efficacy and impacts.

3.1. Risk Analysis Defined

Risk analysis refers to the process of defining and analysing risks posed by an activity to a specific sector i.e. human health, animal health, plant health and life, the economy, trade, society or the environment. It consists of three related elements i.e.

3.1.1. Components of Risk Analysis

Risk Analysis consists of three components i.e. Risk Assessment, Risk Management and Risk Communication.

A. **Risk Assessment:** In Risk Assessment (RA), the likelihood and severity of potential adverse effects of exposure to hazardous agents or activities (i.e., stressors) is characterized (Anderson *et al*., 2004). Risk assessment involves thorough evaluation of available scientific and other evidence. RA can be qualitative or quantitative. Quantitative RA often relies on mathematical modelling.

Risk = Exposure X Hazard

Risk assessment should be flexible to deal with the complexity of real life situations.

B. **Risk Management:** In Risk Management (RM) strategies and actions that may be put in place to minimise or reduce the risk (to an acceptable level) are identified, evaluated and selected.

c. **Risk Communication:** Management of risks requires cooperation and collaboration from a wide range of actors including the general public and as such, effective communication that allows dialogue between regulators and other stakeholders at all stages of the process of risk analysis is a prerequisite.

3.1.2. Rationale for Risk Analysis

Risk Analysis is the basis for decision-making. As outlined previously, most MEAs require Scientific Risk Assessment as a basis for decision making. In the context of IAS, Anderson *et al.*, (2004) identify two broad categories of decisions that can be informed by Risk Analysis i.e.

i. Introduction of potentially invasive non-native species, their vectors, or conveyances prior to establishment. This can lead to decisions, by relevant national authorities as provided for by appropriate national legislation to:
    - Authorize,
    - Allow or permit introduction activities with conditions etc.
ii. The allocation of scarce resources for the control of established invasive species, including rapid response to emerging threats.

3.2. Risk Analysis for Animals

In the context of movement of animals two issues must be analysed as separate, sequential and complementary processes.

- The risk of the non-native animal becoming invasive, and,
- The risk of pathogens being introduced with the animal (OIE, 2011).

Guidance for Assessment of the risk of non-native animals becoming invasive is provided for by "Guidelines for Assessing the Risk of Non-Native Animals Becoming Invasive" (OIE, 2011). In the Guidelines, animal refers to any member of Kingdom Animalia excluding pathogens. **Hazard** refers to a non-native animal whilst **hazard identification** refers to the process of identifying whether an animal is native or not in the importing country or region.

The principal aim of assessing the risk of non-native animals becoming invasive is to provide countries of import with an objective and defensible method of determining non-native animals being considered for import are likely to become harmful to the environment, animal or human health, or the economy. They can also be used to assess the risk of hitchhiker species becoming invasive. The risk analysis may be triggered by:

- A request to import a new species,
- Use of a species for a new purpose,

- Non-native species already in a country where there is likelihood of them being introduced or escaping into the environment.

The Risk Analysis process is summarised in Figure 13.

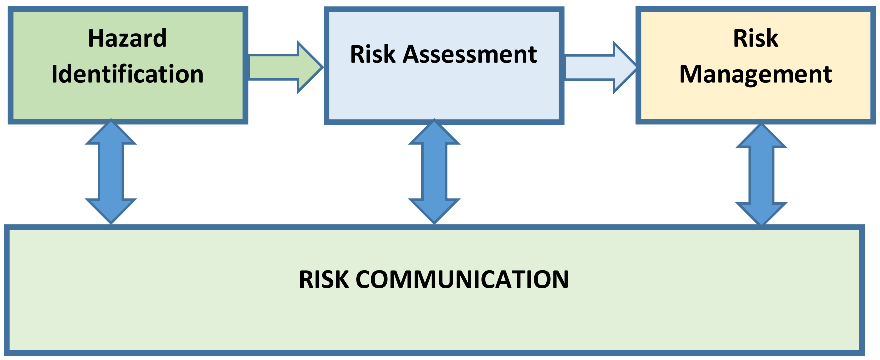

Figure 13: Risk analysis scheme

(from OIE, 2011)

3.2.1. Hazard Identification

Step 1: Hazard Identification: The animal under consideration **is the hazard.** It must be identified as precisely as possible i.e. to the level of species. In some cases, identification to the level of breed, subspecies, hybrid or biotype may be required.

For hitchhiker organisms, hazard identification must identify all species which could potentially produce adverse consequences if introduced in association with the imported commodity (animals or animal products) or the vehicle/vessel or container in which it is imported.

3.2.2. Risk Assessment

Risk assessment facilitates decision making in the face of uncertainty. Risk assessment can either be qualitative or quantitative. Risk assessment should be:

- Based on the best available scientific information available,
- It must be well-documented and supported by appropriate references to literature and other credible sources,
- Opinions of experts and other key stakeholders should be considered, and
- It should be open to review as new information becomes available.

3.2.2.1. Principles of the risk assessment

In addition to the general principles above, the following must also be considered:

- The risk assessment may be carried out at an ecosystem level that may be sub-national,
- The whole range of subjects who may bear the risk i.e. people, other animals or landscapes must be considered hence a **systems-based** approach to risk assessment is required,
- The impact of invasive species may arise both by direct and indirect mechanisms and;
- The effects of IAS may change over time as they are often dependent on prevalent environmental conditions. Climate change is another consideration.

The steps in the RA include Entry Assessment, Establishment Assessment and Consequence Assessment.

3.2.2.2. Entry Assessment

The outcome of entry assessment is the probability of the entry of each of the hazards i.e. the non-native animals under each specified set of conditions with respect to amounts and timing, and how these might change as a result of various actions, events or measures. The probability of the whole process occurring can be described qualitatively (in words) or quantitatively (numerical estimate). Key Questions are shown in Box 1.

BOX 1: Key Questions in Entry Assessment for Animal Imports

Circumstances of entry and containment: Do the circumstances of transportation and containment on arrival prevent escape or release? Examples of Questions that need to be answered include:

- Is the entry intentional or unintentional?
- Are there different commodities, vehicles/vessels or containers that are capable of harbouring the animal under consideration?
- What arrangements are in place for security of containment?
- What are the planned movement, use and holding conditions upon and after arrival?

Biological Factors: What features of the animal may affect its survival during transport and in its initial holding? Issues that need to be considered include:

- Identification i.e. the species, subspecies or lower taxon, sex, age and breed of animals;
- A description of the ability of the organism to survive the conditions and the duration of transport;
- The number of individual animals per importation;
- The ease of escape or release from containment;
- The ability to survive in the environment of the importing country.

If the entry assessment demonstrates no significant risk, the risk assessment does not need to continue.

3.2.2.3. Establishment Assessment

This stage considers the biological conditions necessary for the non-native animals (the hazards) to survive escape or release as well as estimating the probability of establishment and spread occurring. This can be qualitatively or quantitatively. The probability of establishment and spread of the non-native animals is estimated for the local environment considering the number, size, frequency and season of escapes or releases.

Biological factors: This considers features of the animal that may affect the probability of its establishment and spread. Examples of the kind of inputs that may be required shown in Box 2.

BOX 2: Key Questions in Establishment Assessment for Animal Imports

BIOLOGICAL FACTORS TO BE CONSIDERED IN RA

- Does the animal have a history of invasiveness elsewhere?
- What is the propagule pressure i.e. the number and size of releases or escapes?
- Reproductive biology and capacity including:
    - Fecundity,
    - Age of sexual maturity:
    - Breeding frequency:
    - Gestation length
    - Diet;
- Are the animals under consideration wild or domesticated?
- Are the animals under consideration generalist or specialised species?
- What is the range of tolerance and adaptability to environment and climate?
- What is the dispersal mode and capacity?
- What is the longevity of the species?
- What is the density dependence?

3.2.2.4. Consequence Assessment

The focus of consequence assessment is on describing the potential consequences of a given establishment and spread of the animals and estimates the probability of them occurring, again estimated either qualitatively or quantitatively. A causal relationship must exist between the establishment and the identified consequences. The impacts arising from establishment of an alien invasive animal are often difficult to quantify and requires data of sufficient magnitude and quality, which are often not available. These impacts may be direct and indirect as shown in Table 14.

Table 14: Examples of Direct and indirect consequences

Direct consequences	Indirect consequences
• Animal infection, disease, and production losses • Public health consequences.	• Costs of surveillance and control • Compensation costs • Potential trade losses • Adverse consequences to the environment

3.2.3. Risk Estimation

This step integrates the results of the earlier stages to produce a measure of the overall risks associated with the hazards identified at the outset taking into account the whole risk pathway. Examples of outcomes for qualitative and quantitate RAs are shown in Table 15.

Table 15: Examples of outcomes of animal invasiveness risk analysis

Qualitative RA	Quantitative RA
o Estimates of the costs of surveillance and control in descriptive terms e.g. High, medium, low o Estimates of the level of impact on animals, ecosystems or habitats, or people in terms such o Lists of potential evidence-based impacts of significance warranting consideration in decision making; o A qualitative description of the relative risk and range e.g. high to very high etc.	o Numerical estimated costs of surveillance and control, o Estimated numbers of herds, flocks, animals, ecosystems or habitats, or people likely to experience health impacts of various degrees of severity over time; o Probability distributions, confidence intervals, and other means for expressing the uncertainties in these estimates; o Portrayal of the variance of all model inputs; o A sensitivity analysis to rank the inputs as to their contribution to the variance of the risk estimation output; o Analysis of the dependence and correlation between model inputs.

3.3. Import risk analysis (Aquatic Animals)

Trade in live animals, eggs, fingerlings, brood stock and aquatic animal products carry the risk of introducing pathogens into the country. Import risk analysis provides an objective and defensible method of assessing the disease risk associated with aquatic animals, aquatic animal products, aquatic animal genetic material, feedstuffs, biological products and pathological material (OIE, 2016[2]).

For diseases listed in the Aquatic Code as shown in Section 3.4.3.2 of this Manual for fish, a qualitative assessment is often adequate. The import risk analysis must take into consideration the results of an evaluation of the Aquatic Animal Health Services, zoning and compartmentalisation, and surveillance systems that are in place for monitoring aquatic animal health in the country of export.

3.3.1. Hazard identification

This involves identifying pathogens that could potentially produce adverse consequences associated with the importation of the live animal or *commodity*. The hazards identified would be those appropriate to the species being imported, or from which the *commodity* is derived and which may be present in the *exporting country*. It is then necessary to identify whether each *hazard* is already present in the *importing country*, and whether it is a *listed disease* or is subject to control or eradication in that country and to ensure that import measures are not more trade restrictive than those applied within the country. In hazard identification, biological agents are categorised as hazards or not hazards.

3.3.2. Principles of the risk assessment

- The Risk Assessment should be flexible to allow for the range and complexity of real-life situations i.e.
    - The variety of *aquatic animal commodities*
    - The multiple *hazards* that may be identified with an importation, and,
    - Detection and *surveillance* systems, exposure scenarios and types and amounts of data and information
- Both qualitative and quantitative methods are valid that is in accord with current scientific thinking
- The RA should be based on the best available information
- Consistency in *risk assessment* methods should be encouraged and transparency is essential in order to ensure fairness and rationality, consistency in decision-making and ease of understanding by all the interested parties
- Risk Assessment should document the uncertainties, the assumptions made, and the effect of these on the final *risk* estimate.
- Risk increases with an increase in the volume of the commodity

- The *risk assessment* should be amenable to updating as additional information becomes available.

3.3.3. Steps in the risk assessment

As in the case of Terrestrial animals, the Risk Assessment for aquatic animals consist of three steps i.e. Entry assessment, Exposure assessment and Consequence assessment.

3.3.3.1. Entry Assessment

This step involves the biological pathway(s) necessary for an importation activity to introduce a *pathogenic agent* into a particular environment, and estimating the probability of that complete process occurring, either qualitatively (in words) or quantitatively (as a numerical estimate). The entry assessment describes the probability of the entry of each of the *hazards* (i.e. the *pathogenic agents*) or under each specified set of conditions with respect to amounts and timing, and how these might change as a result of various actions, events or measures. Examples of the kind of inputs that may be required in the entry assessment are shown in Box 3.

BOX 3: Key Questions for entry assessment for aquatic animal imports

Biological Factors

- Species, strain or genotype, and age of *aquatic animal*
- Strain of agent
- Tissue sites of *infection* and/or contamination
- Vaccination, testing, treatment and *quarantine*.

Country Factors

- *Incidence* or *prevalence* in the country of export
- Evaluation of *Aquatic Animal Health Services*, *surveillance* and control programmes, and zoning and compartmentalisation systems of the *exporting country*.

Commodity factors

- Whether the *commodity* is alive or dead,
- Quantity of *commodity* to be imported,
- Ease of contamination,
- Effect of the various processing methods on the *pathogenic agent* in the *commodity*, and
- Effect of storage and transport on the *pathogenic agent* in the *commodity*.

If the entry assessment demonstrates no significant *risk*, the *risk assessment* does not need to continue.

3.3.3.2. Exposure Assessment

This step consists of describing the biological pathway(s) necessary for exposure of animals and humans in the *importing country* to the *hazards* (the *pathogenic agents*) from a given *risk* source, and estimating the probability of these exposure(s) occurring, either qualitatively or quantitatively. The probability of exposure to the identified *hazards* is estimated for specified exposure conditions with respect to amounts, timing, frequency, duration of exposure, routes of exposure, and the number, species and other characteristics of the animal and human populations exposed. Examples of the kind of inputs that may be required in the exposure assessment shown in Box 4.

BOX 4: Key Questions for exposure assessment in aquatic animal import RA

Biological factors

- Properties of the agent (e.g. virulence, pathogenicity and survival parameters)
- Genotype of host.

Country factors

- Presence of potential *vectors* or intermediate hosts
- Aquatic animal demographics (e.g. presence of known susceptible species, distribution),
- Human and terrestrial animal demographics (e.g. possibility of scavengers, presence of piscivorous birds)
- Customs and cultural practices
- Geographical and environmental characteristics (e.g. hydrographic data, temperature ranges, water courses).

Commodity factors

- Whether the *commodity* is alive or dead
- Quantity of *commodity* to be imported
- Intended use of the imported *aquatic animals* or *products* (e.g. domestic consumption, restocking, incorporation in or use as *aquaculture feed* or bait)
- Waste disposal practices.

If the exposure assessment demonstrates no significant risk, the risk assessment may conclude.

3.3.3.3. Consequence assessment

This step involves describing the relationship between specified exposures to a biological agent and the consequences of those exposures. A causal process should exist by which exposures produce adverse health or environmental consequences, which may in turn lead to socio-economic consequences. The consequence assessment describes the potential consequences of a given exposure and estimates the probability of them occurring. This estimate may be either qualitative or quantitative. Examples of consequences include:

Direct consequences:

- *Aquatic animal infection*, *disease*, production losses and facility closures,
- Public health consequences.

Indirect consequences

- S*urveillance* and control costs
- Compensation costs
- Potential trade losses
- Adverse, and possibly irreversible, consequences to the environment.

3.3.4. Risk estimation

This step consists of integrating the results of the entry assessment, exposure assessment, and consequence assessment to produce overall measures of *risks* associated with the *hazards* identified at the outset. Thus *risk* estimation takes into account the whole of the *risk* pathway from *hazard* identified to unwanted outcome. For a quantitative assessment, the final outputs may include:

- The various populations of *aquatic animals* and/or estimated numbers of *aquaculture establishments* or people likely to experience health impacts of various degrees of severity over time,
- Probability distributions, confidence intervals, and other means for expressing the uncertainties in these estimates
- Portrayal of the variance of all model inputs
- A sensitivity analysis to rank the inputs as to their contribution to the variance of the *risk* estimation output
- Analysis of the dependence and correlation between model inputs.

3.4. Risk Assessment for aquatic animals and aquatic animal products for human consumption

Safety assessment of aquatic animals and aquatic animal products for human consumption must consider:

- The form and presentation of the product,
- The expected volume of waste tissues generated by the consumer and,
- The likely presence of viable pathogenic agent in the waste.
- The nature of the retail pathway e.g. direct wholesale distribution vs. further downstream action e.g. gutting, cleaning, filleting, freezing, thawing, cooking, unpacking, packing or repackaging.

Assumptions made include:

i. The aquatic animals or aquatic animal products are used for human consumption only;
ii. Waste may not always be handled in an appropriate manner that mitigates the introduction of the pathogenic agent (the level of risk is related to the waste disposal practices in each Member's country or territory);
iii. Treatment or processing prior to importation is conducted in accordance with Good Manufacturing Practices, and;
iv. Any other steps in the treatment, processing and subsequent handling of the aquatic animals or aquatic animal products prior to importation do not jeopardise the safety of the traded aquatic animals or aquatic animal products.

3.5. Pest Risk Analysis (Plants)

Pest risk analysis (PRA) is a science-based process that provides the rationale for determining appropriate phytosanitary measures for a specified PRA area. It is based on an evaluation of technical, scientific and economic evidence to determine whether an organism is a potential pest of plants and, if so, how it should be managed. The major international standard forPRA is provided by the IPPC under ISPM 11. It involves evaluation of technical, scientific and economic evidence to determine whether an organism is a potential pest of plants and, if so, how it should be managed (IPPC Secretariat, 2004[1]).

The IPPC defines a pest as any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant product. This then includes other plants, bacteria, fungi, insects and other animals, mites, molluscs, nematodes, and viruses.

The IPPC recognizes and defines two categories of regulated pests of plants i.e.:

- **Quarantine pests:** A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled
- **Regulated, non-quarantine pests (RNQP):**A pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party. RNQPs are usually widely distributed in the country under consideration.

The PRA helps to determine whether a pest fits into either of these two categories as well as whether or not any phytosanitary measures are necessary, and if so their strength.

In the case that that the organism in question is a quarantine pest, the process goes on to determine the probability of introduction and spread as well as the magnitude of potential consequences based on scientific, technical and economic evidence. If the pest risk is deemed unacceptable, the Risk Management options to reduce the pest risk to an acceptable level are proposed. These pest risk management options may be used to establish phytosanitary regulations. Variables that may be considered in the PRA are shown in BOX 5.

The PRA seeks to answer the following Questions:

- Is the organism a pest?
- What is the likelihood of introduction, establishment and spread?
- How much economic (including environmental and social) damage (unacceptable impacts) does it cause?
- What can be done to mitigate unacceptable impacts?

The PRA consists of three stages i.e. initiation, PRA and Risk Management. Risk communication occurs throughout the process.

3.5.1. Stage 1: Initiation

Initiation is aimed at identifying pest(s) and pathways which are of quarantine concern and should thus be considered for risk analysis in relation to the identified PRA area.

BOX 5: Variables that may be considered in the PRA

- Strength of association between species and commodity/vector/corridor at point of export
- Volume of the commodity/vector/corridor imported
- Frequency of importation
- Species survivorship and population growth during transport/storage
- Suitability of environment for species establishment in the importing region
- Appropriateness of the time of year of importation for species establishment
- Ease of species detection within consignments/vectors/corridors
- Effectiveness of management measures e.g. fumigation, inspection regime
- How widely the commodity/vector is subsequently distributed in the importing region
- Likelihood of transfer from the commodity/vector/corridor to a suitable habitat (EPPO, 2007; Hulme, 2009)

3.5.1.1. Initiation points

The PRA may be triggered by three factors i.e.

- Identification of a pathway that presents a potential pest hazard, (Pathway) e.g. where a country is considering importing a commodity from a new country (plant, plant product, LMO etc., or, a case where the country is considering a commodity it has never imported. The NPPO needs to develop a list of all pests likely to be associated with the commodity or pathway. Data sources that can be consulted include

- Official documents and other sources,
- Databases,
- Scientific and other literature,
- Expert consultation.

As much as possible, the pest list must be prioritised, again based on expert judgement. If no potential quarantine pests are identified as likely to follow the pathway, the PRA may stop at this point. The rationale must be recorded.

3.5.1.2. Identification of PRA Area

The area for which the PRA is being carried out must be clearly defined to facilitate ease of identification of relevant information and to ensure that all considerations in the PRA (i.e. assessment of potential distribution or potential impacts, consideration of other influences, or evaluation of phytosanitary measures) apply to the same area. The PRA Area may be a country, a number of countries falling under a RPPO etc.

3.5.1.3. Information gathering

Information gathering happens throughout the PRA. During Initiation, information required includes:

- The identity of the pest(s),
- The present distribution of the pest(s) and association with host plants, commodities etc.

More information will be gathered as required to reach necessary decisions as the PRA continues. Information for PRA may come from a variety of sources including sources that are not normally used by NPPOs. If a PRA has previously been carried out nationally or internationally, its validity should be determined and the possibility of using a PRA for a similar pathway or pest investigated.

3.5.1.4. Conclusion

At the close of initiation, the pests and pathways of concern will have been identified and the PRA area will have been defined. Relevant information will also have been collected.

3.5.2. Stage 2: Pest Risk Assessment

Pest assessment consists of three interrelated steps as follows.

3.5.2.1. Pest categorization

This step is aimed at identifying which of the pests identified in the previous stage require a PRA i.e. whether the criteria in the definition for a quarantine pest are satisfied. This is especially important when a Pathway associated with a commodity is being considered. Categorization enables elimination of those organisms that do not require detailed analysis. Organisms that already occur and are not managed in the country doing the PRA cannot be considered pests. Elements of categorization include:

- **The identity of the pest**, stated as clearly and precisely as possible e. Latin name (genus and species), common names etc.
- **Presence (or absence) in the PRA area:** The organism must be absent in at least part of the PRA area.
- **Regulatory status in the PRA area:** If the pest is present but not widely distributed in the PRA area, it should either be under official control or expected to be under official control in the near future.
- **Potential for economic and environmental consequences:** The potential to cause harm in the PRA area must clearly demonstrated.

The outcome of categorization is a decision as to whether the organism under consideration has the potential to be a quarantine pest. If it does not fulfil any of the criteria, the PRA need not continue.

3.5.2.2. Assessment of the probability of introduction and spread

Introduction in the context of the PRA includes both introduction and spread. Entry of a pest into a country would require a series of events to occur in sequence and with some probability from the point of origin to the new area. Assessing the probability of introduction requires an analysis of each of the pathway(s) with which a pest may be associated from its origin to its establishment into the PRA area. The assessment of probability of spread is based primarily on biological considerations similar to those for entry and establishment. The following need to be considered during this stage:

- **Identification of pathways for a PRA initiated by a pest:** For a PRA that has been initiated for a specific pest, with no particular commodity or pathway under consideration, the potential of all probable pathways should be considered, including those that may not currently exist. The higher the number of pathways, the higher the likelihood of introduction. Other pathways that need to be considered include other types of commodities, packing materials, persons, baggage, mail, conveyances and the exchange of scientific material should be considered where appropriate. The potential for entry by natural means should also be assessed, as natural spread is likely to reduce the effectiveness of phytosanitary measures.

- **The likelihood of the pest being associated with spatially or temporally with the pathway at origin**: This will be determined by amongst others, the prevalence of the pest in the source area, occurrence of a life stage that is associated with the commodity, pest management practices in the country of origin etc.
- **Probability of survival during transport and/ storage:** This will depend on the stage of development of the pest that is associated with the commodity but probability of survival during transport/ storage is generally likely to highly likely (Petter *et al.,* 2009).
- **Likelihood of the pest surviving current pest management procedures including phytosanitary measures applied from source to destination**, and,
- **Probability of transfer to a suitable host:** This is dependent on a number of factors including dispersal mechanisms, the number of destination points the commodity will be sent to inside the PRA area etc.

Probability of introduction = (Probability of entry) X Probability of establishment) X (Probability of spread)

- **Assessment of potential economic consequences (including environmental impacts):** The impacts of the pest may be direct or indirect. To assess the potential economic impact of the pest, the assessor must collect information should be obtained from areas where pest occurs naturally or has been introduced and compare this with the PRA Area. This applies to:
  - Pests affecting wild/unmanaged plants
  - Weeds and/or invasive plants and,
  - Pests affecting plants through effects on other organisms.

The impacts may be direct or indirect and they can be economic, environmental or social. The impacts can be described quantitatively e.g. monetary terms or they can be described qualitatively. A combination of the two can also be used. Assessment of the magnitude of the impact, should consider both the direct consequences of the pest introduction and spread plus the magnitude of the impacts associated with the mitigation measure taken against the pest.

Magnitude of impact = (Economic impacts) + (Environmental impacts) + (Social impacts)

The overall risk is then estimated by combining the probability of introduction with the magnitude of the impact i.e.

Pest Risk = (Probability of introduction) x (Magnitude of impact)

This can be done through use of a Risk Matrix. The Risk Matrix helps decision-makers to visualise the results of Risk Assessment and thus facilitate ease of decision-making. Events that have a high likelihood of occurring and have high economic/environmental/social impact warrant higher and more urgent action. An example of a Risk Analysis Matrix e.g. shown below:

	Economic/environmental/social consequences				
Likelihood	Negligible	Low	Medium	High	Extreme
Extremely high	H	H	E	E	E
High	M	H	H	E	E
Medium	L	M	H	E	E
Low	L	L	M	H	E
Negligible	L	L	M	H	H

Key:

- **E** Extreme risk - specific action is immediately required to reduce risk
- **H** High risk - specific action is required, generic risk treatment plans should be adopted as soon as possible in the interim.
- **M** Moderate risk - adoption of generic risk treatment plans will reduce the risk to suitable levels.
- **L** Low risk - manage through routine procedures.
- **N** Negligible risk.

Risk Analysis Matrix for Colorado Potato Beetle in Australia

(Source http://pbt.padil.gov.au/index.php?q=node/135&pbtID=92)

The PRA process and decision points are shown in Figure 14. Flow charts summarising various stages of the PRA are included as Annex VII.

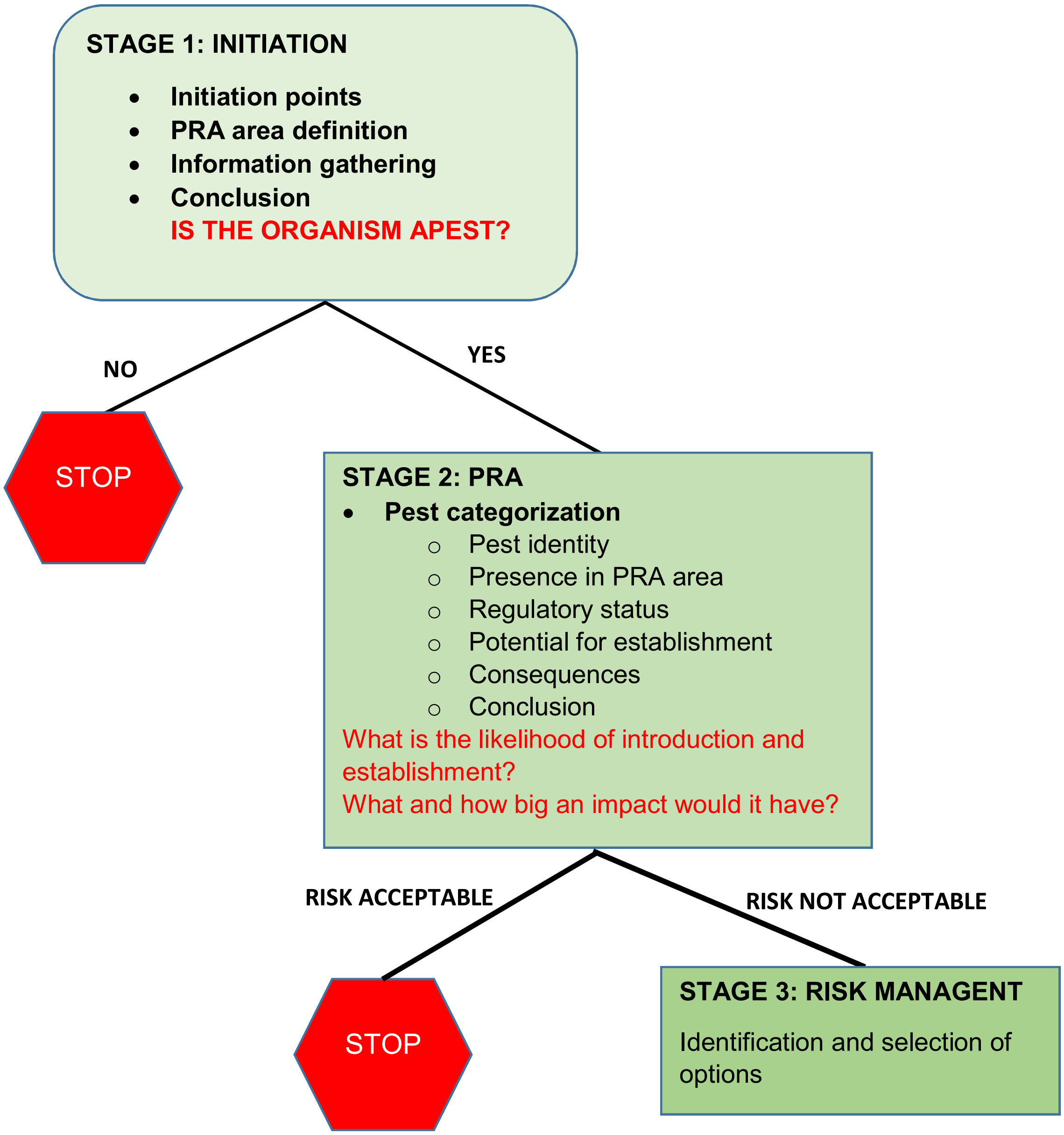

Figure 14: PRA Process

3.5.3. Risk Assessment for LMOs as Plant Pests

ISPM 11 also provides for analysis of environmental risks and LMOs. The PRA for LMO plants follows the same process as a PRA starting with initiation. For LMOs, the aim of the initiation stage is to identify LMOs that have characteristics of a potential pest and which thus need further assessment. Plant pest risk from LMOs may be due to:

- The LMO itself,
- The combination of genetic material (e.g. gene from plant pests such as viruses) or,
- The consequences of the genetic material moving to another organism.

To be classified as a pest, the LMO must be injurious or potentially injurious to plants or plant products under conditions in the PRA area. The nature of the effects can be both direct and indirect. Annex 3 of ISPM 11 provides guidance for determining the potential of an LMO to be a plant pest. The characteristics that need to be considered are shown in Table 16.

Table 16: Phytosanitary issues of LMO Plants

Type of Effect and Example(s)
A. Changes in adaptive characteristics which may increase the potential for introduction or spread e.g.: • Tolerance to adverse environmental conditions, • Reproductive biology, • Dispersal ability of pests, • Growth rate or vigour, • Host range • Pest resistance • Pesticide resistance or tolerance • Herbicide resistance or tolerance.
Transfer of pesticide or pest resistance genes to compatible species • Potential to overcome existing reproductive and recombination barriers resulting in pest risks, • Potential for hybridization with existing organisms or pathogens to result in pathogenicity or increased pathogenicity.
Adverse effects on non-target organisms e.g. • Changes in host range of the LMO, • Effects on other organisms e.g. biological control agents, beneficial organisms, or soil fauna and microflora etc. that result in a phytosanitary impact (indirect effects) – • Capacity to vector other pests, and • Negative direct or indirect effects of plant-produced pesticides on non-target organisms beneficial to plants.
Genotypic and phenotypic instability e.g. • Reversion of an organism intended as a biocontrol agent to a virulent form.
Other injurious effects including e.g.

- Phytosanitary risks presented by new traits in organisms that do not normally pose phytosanitary risk,
- Novel or enhanced capacity for virus recombination, trans-encapsidation and synergy events related to the presence of virus sequences
- Phytosanitary risks resulting from nucleic acid sequences (markers, promoters, terminators etc.) present in the insert.

The range of LMOs that may need to be assessed for phytosanitary risk include:

- LMOs for use as food crops / fodder
- LMOs for use as ornamental plants or managed forests;
- Uses in bioremediation
- Use in in industrial applications etc. and others.

The possible outcome of this initial assessment are:

- **The LMO is a potential phytosanitary pest:** If this is the case, the LMO would then be subject to Stages 2 and 3 of the PRA.
- **The LMO is not a phytosanitary pest:** If the LMO is not a phytosanitary pest it, the PRA need not continue. The LMO would then be subject to the same phytosanitary measures as its conventional counterpart.

In the context of LMO risk assessment:

- ***Hazard*** is defined as the potential of an organism to cause harm to human health and/or the environment (UNEP, 1995).
- **Exposure** refers to the route and level of contact between the likely potential receiving environment and the LMO or its products.

3.6. Environmental Risk Assessment of LMO Plants

The European Food Safety Authority (EFSA) has developed guidance for Environmental Risk Assessment (ERA) of LMO plants. The Guidance documents does not address co-existence, socio-economic considerations etc. The EFSA suggests risk assessment should be conducted in a scientifically sound manner based on available scientific and technical data and common methodology for the identification, gathering and interpretation of the relevant data. The guidance also requires that tests, measurements, and data generated should be clearly described. Similarly, any assumptions made during the ERA must also be highlighted (EFSA, 2010).

The objective of the ERA is to identify and evaluate potential adverse effects of the GM plant on the receiving environment(s) where the GM plant will be released. The effects can be direct and indirect, immediate or delayed (including cumulative long-term effects). The process involves comparing the potential impacts of the GM plant against its non-GM plant comparator. The underlying assumption of the comparative assessment for GM plants is that the biology of traditionally cultivated plants from which the GM plants have been derived, and the appropriate comparators is well known. In the ERA, it is appropriate to draw on previous knowledge and experience and to use the appropriate comparator in order to highlight differences associated with the GM plant in the receiving environment(s) (EFSA, 2010).

The guidance advocates a case by case assessment allowing for variation in the information requirements depending on the species of GM plants concerned, the introduced gene(s), the intended use(s) and the potential receiving environment(s), taking into account specific cultivation requirements and the presence of other GM plants in the environment. The ERA follows six steps i.e.

i. **Problem formulation including hazard identification**: This involves identification of characteristics of the GM plant that are capable of causing potential adverse effects to the environment (i.e. the hazards). The nature of these effects and the pathways of exposure through which the GM plant may adversely affect the environment must also be described. Also in this step, assessment endpoints are defined and specific hypotheses to guide the generation and evaluation of data in the next risk assessment steps (i.e. hazard and exposure characterisation) are set. Both existing scientific knowledge and knowledge gaps are considered. The characteristics of the GM plant are compared with those of the appropriate comparator (plant).

Problem identification should be done on a case by case basis and should, on a case by case basis, taking into account the GM plants and trait(s) concerned, consider their intended use(s), and the potential receiving environment(s) relevant to the GM plant. This includes:

- Occurrence of compatible wild and weedy relatives of GM plants,
- Effects of production systems on the interactions between the GM plant and the environment

Relevant baseline(s) of the receiving environment(s), including production systems, indigenous biota and their interactions, should be established to identify any potentially (harmful) characteristics of the GM plant. The receiving environment is characterized by interactions between:

A. The GM Plant,
B. The Geographic zone, and;

C. Management systems as shown in Figure 15 which also shows examples of factors under each.

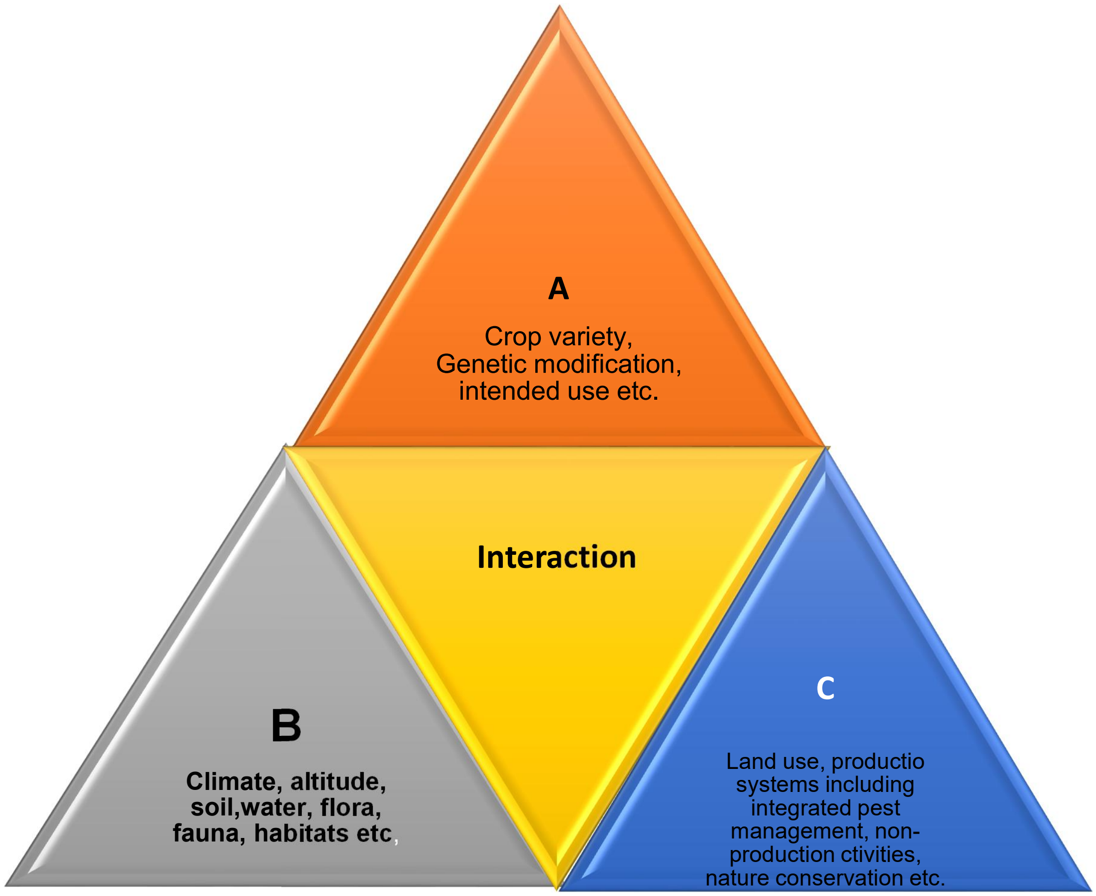

Figure 15: Components of the receiving environment for LMO plants

The receiving environment should ideally be selected to be representative of the range of geographic factors present in the country and should as much as possible include a worst case scenario.

ii. **Hazard characterisation:** This refers to the qualitative and/or quantitative evaluation of environmental harm associated with the hazard as set out in one or more hypotheses derived from problem formulation. The magnitude should ideally be expressed in quantitative rather than qualitative terms. Identified hazards can also be placed on an ordered categorical descriptive scale e.g. "*high*", "*moderate*", “low” or "*negligible* with the provision that the terms used are described in quantitative scales.

iii. **Exposure characterisation:** In this step, the exposure likelihood of adverse effects occurring, is evaluated for each hazard identified. Likelihood of exposure can be expressed either qualitatively using an ordered categorical description e.g. "*high*", "*moderate*", "*low*" or "*negligible*") or quantitatively as a relative measure of probability range0 to 1, where

0 Implies impossibility; 1 represents certainty.

iv. **Risk characterisation:** This is done by combining the magnitude of the consequences of a hazard and the likelihood of the consequences occurring. If a hazard has more than one adverse effect, the magnitude and likelihood of each individual adverse effect should be assessed. The magnitude of the consequences of the hazard ("*high*", "*moderate*", "*low*" or "*negligible*", with an explanation of what is meant by these terms).

v. **Risk Management:** This step seed to manage any risks identified in the earlier steps. The objective is to reduce the level of risk to an acceptable level. Risk management strategies aim to reduce the risk and/or exposure. The efficacy of the proposed Risk Management strategies must also be assessed. Examples of Risk Management measures that can be considered include:
   - Reducing transgene movement by lowering sexual fertility,
   - Controlling the progeny of GM plants resulting from gene flow.
   - Controlling volunteers, feral populations or wild relatives

vi. **Overall risk evaluation and conclusions:** The outcome of the Risk Assessment could be:
   - The impact of the GM plant and/or hybridising relatives in the production system, particularly through increased weediness and more intense weed control;
   - The impact of the GM plant and/or hybridising relatives in semi-natural and natural habitats, through change in invasiveness or reduction of biodiversity or ecological function;
   - Why any anticipated harm may be considered acceptable; and
   - Any risk management measures may be required to mitigate any harm

Figure 16shows a summary of the EFSA ERA Scheme. Annex VI shows some key questions for Risk Analysis of LMOs in the context of Cameroon.

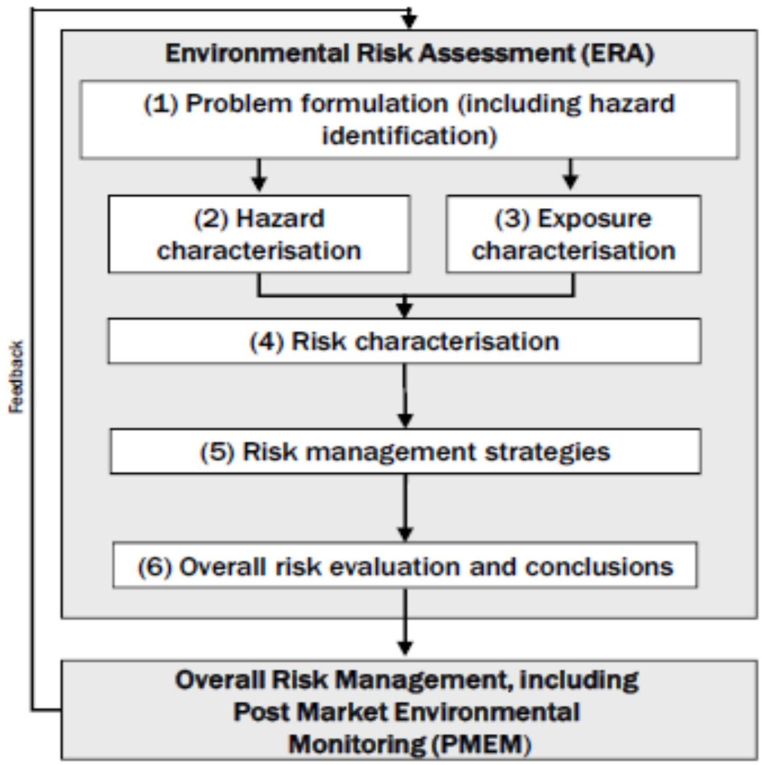

Figure 16: EFSA ERA Process

3.7. Environmental risk assessment of animals

The ERA for GM animals follows a similar scheme to the ERA for GM plants.

i. **Problem formulation including identification of hazard and exposure pathways**: This step involves identification of the hazards associated with the GM animal. This is done by comparing the characteristics of the GM animal with a comparator in order to find differences in the GM animal that may lead to harm/ changed levels of harm. This requires use of all relevant information on exposure through which the GM animal may adversely affect the receiving environments. Possible exposure pathways include:
    - Those resulting from the intended uses,
    - Expected management of the GM animal,
    - Possible escape into other receiving environments
    - Accidental release into the environment of viable eggs and animals during transport and processing etc.
    - Unintended exposure through accidental intake and contact with GM animals or processed GM products
    - All forms of indirect exposure e.g. through effluents from GM animals

- Changes in pests and pathogens associated with the GM animal.

The assessment must be linked to end-points which can be drawn from national protection goals as elaborated in national regulatory instruments in order to focus on measurable aspects of the environment. Examples of protection goals include conservation of biodiversity, sustainable use of natural resources etc. Limits of concern must be clearly defined. Baselines of the receiving environments must also be established using available data to provide a reference point for future changes. Problem formulation must thus:

- Identify simultaneously and on a case-by-case basis:
  - The characteristics of the GM animal, taking into account the associated management of the production systems that can cause adverse direct or indirect effects on the environment, including human and animal health; and
  - The relevant aspects of the receiving environments, including human and animal health, that need to be protected from harm according to environmental protection goals as elaborated in national legislation including suitable protection units, e.g. individuals, populations, communities, guilds as well as the spatial and temporal scale of protection.
- Define the intended use(s) of the GM animal, and the intended management regimes that will be applied in order to identify the environmental exposure pathways;
- Identify the potential adverse effects linked to those harmful characteristics.

If potential adverse effects are identified, the problem formulation should then:

- Define assessment endpoints being representative of the previously identified protection goals;
- Define measurement endpoints as measurement units for both hazard and exposure;
- Describe interrelationships between assessment and measurement endpoints and relate these to protection goals;
- Define relevant baselines used as points of reference to determine the minimum relevant ecological effect that is deemed of sufficient magnitude to cause harm;
- Formulate testable hypotheses that are clearly phrased and easily transferable to data to be generated or evaluated;
- Consider possible uncertainties (e.g. knowledge gaps, methodological limitations).

ii. **Hazard characterisation:** This refers to the qualitative and/or quantitative evaluation of environmental harm, including harm to human or animal health, associated with the hazard against the baseline expressed ideally in quantitative terms.

iii. **Exposure characterisation:** Exposure characterisation estimates the likely exposure of other biota and the environment to the GM animal quantitatively. The analysis should take into account the nature, magnitude, frequency and duration of the exposure to the GM animal. The exposure to the GM animal is itself related to the intended use of the GM animal and its level of release. Other issues to be considered include:
   - Propagule pressure (the combined effect of the number of individuals released into the environment and the number of release events over a specified period of time)
   - Escape frequencies where applicable.

iv. **Risk characterisation:** This is defined in the Guidance Document as the quantitative or semi-quantitative estimate of the probability of occurrence and magnitude of harmful effect(s) based on problem formulation, hazard and exposure characterisation. Risk is characterised by combining the magnitude of the consequences of each hazard (quantified for example as high, moderate, low or negligible) with the likelihood of the consequences related to hazard occurring in the receiving environment (also characterized on a scale as high, moderate, low or negligible). The overall uncertainty associated with each risk and the assumptions must be considered. The analysis must consider representative exposure scenarios including a worst case scenario. This can include high rates of uptake, illegal use, poor management etc.

v. **Risk management strategies:** If risks or uncertainties are identified risk management strategies to manage these must be proposed to cover the whole range of scenarios including the worst case scenario. These must be in line with national protection goals and the receiving environments. The components of the receiving environment for GM animals are shown in Figure 17. The risk management strategy can take the form of reducing exposure and/or reducing the hazard. Examples of such measures include:
   - Physical confinement,
   - Infertility.

Measures for post-release monitoring and surveillance must also be proposed.

vi. Overall risk evaluation and conclusion

This will be influenced by outcomes of preceding steps taking into account levels of uncertainty, the weight of evidence as well as the proposed risk management strategies n each receiving environment. The overall risk evaluation can be expressed qualitatively or quantitatively. For any identified risks, the scale and likelihood of harm associated with these risks must be described.

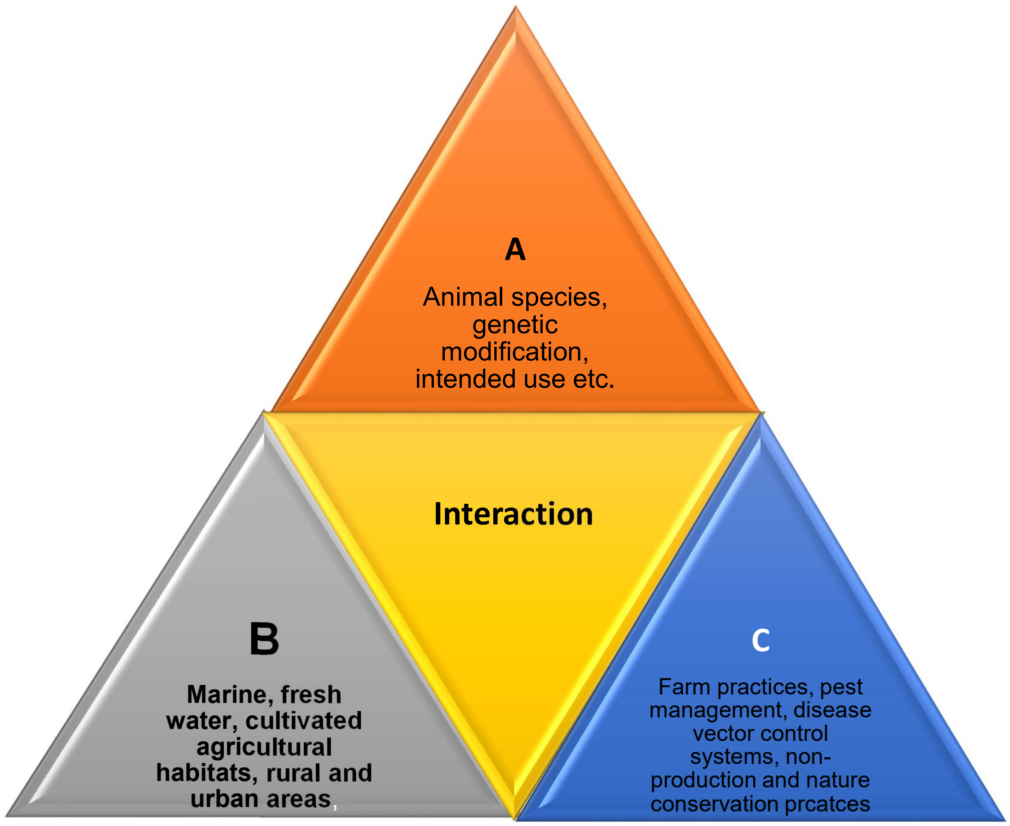

Figure 17: Components of the receiving environment for LMO animals

3.8. Risk Assessment and Management Ballast Water and Sediment

Potential hazards that need to be assessed in the context of ballast sea water and sediment are shown in Table 17.

Table 17: Issues to be considered in ballast sea water and sediment risk assessment

A. **Impacts on land and sea**	
Biological invasion	• Disruption of ecosystem balance • Change in nutrient cycles • Food web disturbance • Biological, chemical and/or physical alteration of habitats • Change in indigenous species distribution • Decline in indigenous species population (e.g. increased competition) • Deterioration of water quality, etc.
Introduction of diseases and parasites	E.g. the parasite *Myxobolus cerebralis* can affect salmon and Salmonella can infect cattle

B. Public health impacts	
Pathogens in water or seafood	*e.g. Escherichia coli*, *Vibrio cholerae* and *Cryptosporidium*
Food poisoning caused by biotoxins	E.g. species of phytoplankton produce toxins that accumulate in fish and shellfish and may therefore be transmitted to humans (WHO, 2003). They have the potential to cause diarrheic, amnesic, paralytic and neurotoxic poisoning, and **possibly even** death.
C. Economic and social impacts of invasions on fisheries, aquaculture and tourism	
Impacts on fish/shellfish stocks	• Voracious predators; • Pathogens, biotoxins or parasites; • Lack of food because primary production is disrupted; • Disturbance of their habitats
Decline of amenity value	• Proliferation of some species e.g. jellyfish,
D. Decline Disruption of port activities	
• Epidemic disease outbreak • Harmful algal bloom • Maintenance dredging resulting in the **resuspension** of contaminated sediment and the **release** of harmful organisms and/or toxic substances	

GEF-UNP-IMO (2013) suggest establishment of a multi-stakeholder working group for assessment of risks associated with ballast water as shown in Table 18.

Table 18: Composition of the multi-stakeholder working group for assessment of risks associated with ballast water

Stakeholder group	Stakeholder
Government authorities & policy stakeholders	• Maritime Administration • Coast guard/Navy • Port authorities • Local authorities
Public health & environmental protection	• Public health services • Laboratories • Agency in charge of drinking water distribution • Agency in charge of seafood safety, fisheries and aquaculture • Veterinary/quarantine services • Environmental protection services • Hydrographic and oceanographic services
Industries & businesses	• Chamber of commerce • Representative of pilots • Representative of the shipping industry • Representative of the fishing and aquaculture industries • Representative of the tourism industry
Other stakeholders	• Universities and research institutes • Non-governmental organizations and trade unions

GEF-UNP-IMO (2013) suggests the scheme shown in Figure 18for risk assessment and risk management.

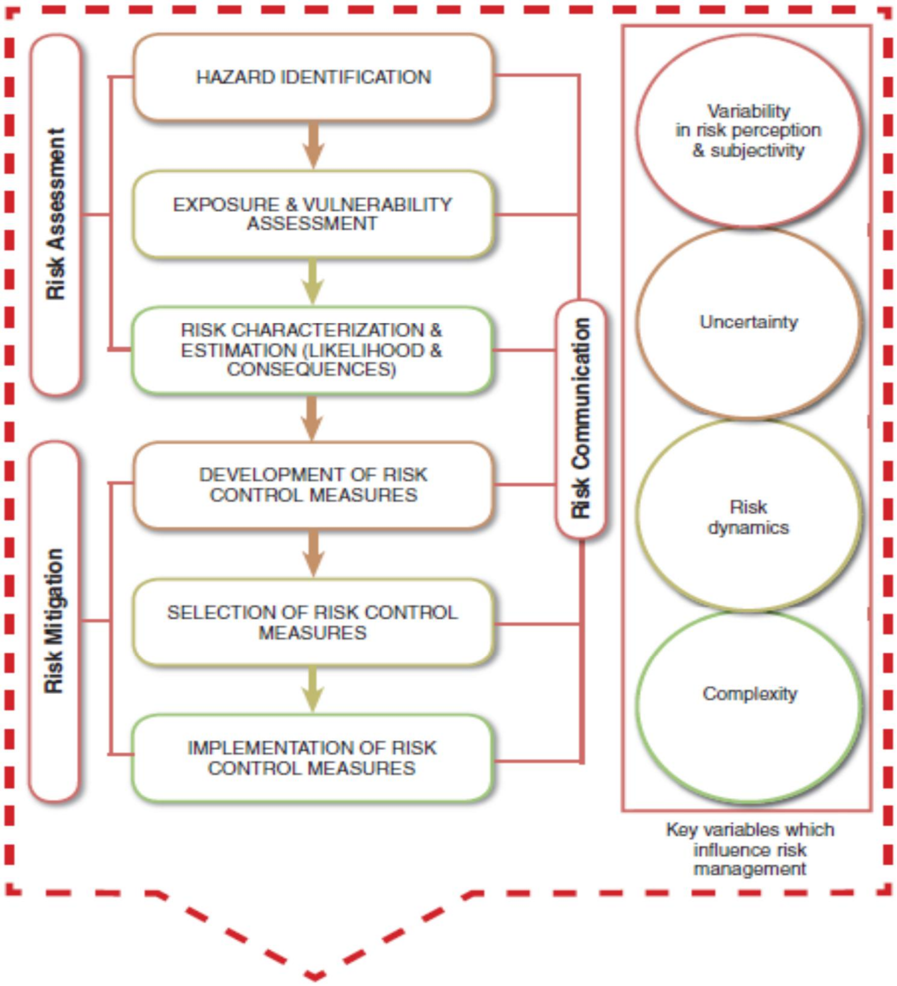

Figure 18: Risk assessment and risk management for ballast sea water and sediment

Source: GEF-UNEP-IMO (2013)

Some actions associated with ballast water and sediment management are shown in Table 19.

Table 19: Actions associated with ballast water management

ON BOARD THE SHIP	ASHORE
• Ballast Water Exchange operations • Sediments removal • Ballast tank inspection • On-board transport, storage, handling and use of active substances • Operation, repair and maintenance of BWMSs • Removal, cleaning and replacement of filters	• Transport, installation, repair and maintenance of Ballast Water Management System (BWMS) • Ballast water and sediments sampling • Ballast tank inspection • Sediments removal • Transport, storage, handling and delivery of active substances • Commissioning of BWMs

3.9. Risk Management

Risk Management (RM) seeks to ensure a balance between the national protection objectives in the specific biosecurity sector on one hand and minimising negative impacts on trade on the other. RM involves identification and selection of measures to manage the negative consequences associated with the activity under consideration. Risk management enables the country to attain an adequate level of protection as elaborated in national policy whilst minimising the negative impacts on trade. Sound science lies at the core of Risk Assessment. In RM, science is balanced against protection of health, economic considerations, technical feasibility, cost-effectiveness etc. (FAO, 2007).

RM consists of:

- **Risk evaluation:** This comparing the risk estimated in the risk assessment with national protection goals i.e. the Country's appropriate level of protection.
- **Identification selection and of risk management measures:** This involves:
    - Identifying measures to reduce the risk associated with an importation,
      Evaluating their efficacy (i.e. the degree to which an option reduces the likelihood and/or magnitude of adverse biological and economic consequences). Evaluating the efficacy of the options selected is an iterative process that involves their incorporation into the risk assessment and then comparing the resulting level of risk with that considered acceptable. The evaluation for feasibility normally focuses on technical, operational and economic factors affecting the implementation of the risk management options.
    - Evaluating their feasibility and,
    - Selecting an option in line with the member country's appropriate level of protection as shown in Figure 19 The option that gives an acceptable level of protection (at minimal cost) should be selected.
- **Implementation**: This refers to following through with the risk management decision and ensuring that the risk management measures are in place.
- **Monitoring and review:** This is the ongoing process by which the risk management measures are continuously audited to ensure that they are achieving the results intended.

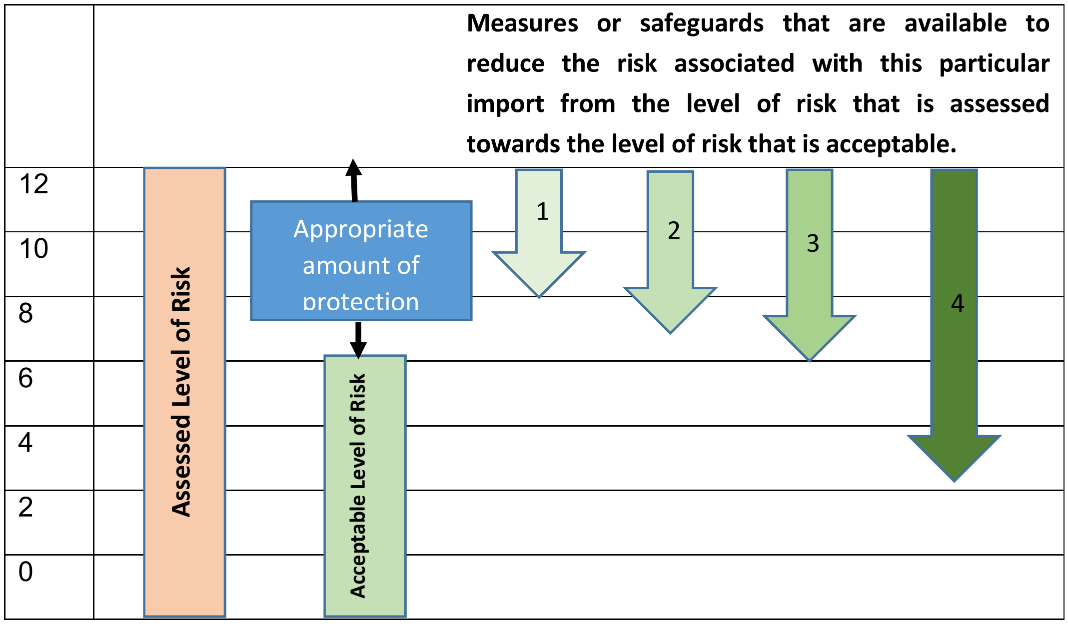

Figure 19: Representation of the relationship between assessed risk, acceptable level of risk and appropriate level of protection

(Modified from Pharo, 2002)

3.9.1. Risk Management (PRA)

It is not possible to achieve zero risk despite all efforts that may be put in place. Risk management identifies, evaluates and selects measures to reduce the risk to a suitable or acceptable level. In line with requirements of ISPM No. 1 (*Phytosanitary principles for the protection of plants and the application of phytosanitary measures in international trade*, 2006) countries must elaborate policies for risk management as part of their phytosanitary measures. This also involves settling the level acceptable risk. ISPM No. 11 (2004) stipulates the following considerations for selection of Risk Management options, which include several of the phytosanitary principles outlined in ISPM No. 1 (2006):

- Phytosanitary measures must be cost-effective and feasible;
- They must have "minimal impact" i.e. they must not be more trade restrictive than necessary to reduce the level of risk to an acceptable level,
- They must be in line with the Principle of "equivalence" i.e. if different phytosanitary measures with the same effect are identified, they should be accepted as alternatives,
- They must be non-discriminatory.

The following options are generally adopted to mitigate plant pest risks:

- Measures for preventing or reducing infestations in the growing crop, e.g., pest management practices, monitoring, etc.

- Measures for ensuring that the area, place, or site of production is free from the pest, e.g., surveillance and monitoring, treatments, etc.
- Options for application to consignments and commodities, e.g., post-harvest treatments, inspections, etc.
- Options for other types of pathways, e.g., certification of packing materials, transportation pathways, etc.
- Options to be applied within the importing country, e.g., inspection at point of entry, end-use restrictions, treatments, etc.
- Prohibition or restriction of commodities, and
- Requirement for phytosanitary certificate or other compliance measures.

3.9.2. Risk Management (Public health)

The Heath sector has traditionally focussed on emergency response but the WHO is calling for a broader focus to a more proactive approach which emphasises prevention and mitigation, development of community and country capacities to provide timely and effective response and recovery. These measures are highly dependent on resilient health care systems based on primary care at community level (WHO, 2013). Guidance for Risk Assessment in Public Health is provided by WHO (2012). In the context of public health, the outcome of risk assessment forms the basis of control measures. The level of risk assigned gives an indication of the urgency and stringency of the control measures. A risk matrix as shown in Table 20 can be used to rank control measures according to their likelihood to prevent further spread.

Table 20: The likelihood that a control measure will prevent further spread

Level	Definition
Highly likely	Will probably prevent additional cases in most circumstances
Almost certain	Is expected to prevent additional cases in most circumstances
Likely	Will prevent additional cases some of the time
Unlikely	Could prevent additional cases some of the time
Very unlikely	Could prevent additional cases under exceptional circumstances

(From WHO, 2012)

Alternatively, Table 21 which assesses the consequences of implementing the control measures.

Table 21: Consequences of implementing control measures

Level	Definition
Minimal	Limited social impact No ethical considerations No or very little economic impact No or very little political impact
Minor	Minor social impact Limited ethical considerations Limited economic costs Some political impact
Moderate	Moderate social impact Some ethical considerations Moderate economic costs Moderate political impact
Major	Major social impact Significant ethical considerations Major economic costs Major political impact
Severe	Severe social impact Considerable ethical considerations Considerable economic costs Severe political impact

(From WHO, 2012)

The control measures must be assessed for their Social, Technical and Scientific, Economic, Environmental, Ethical, Policy & Political (STEEEP) impacts. WHO (2012) stresses that assessment of each control measure must take into account the whole range of STEEEP impacts. Criteria for selecting control measures include:

- **Effectiveness of the control measures:** Measures that are most likely to reduce spread are most suitable.
- **Consequences of implementing the control measures:** Measures that are most likely to have minor to moderate STEEEP consequences are preferred.
- Where the event is determined as a high risk (i.e. where a precautionary approach is justified) control measures that have a limited chance of preventing additional cases or spread of the hazard may be acceptable (WHO, 2012).

3.9.3. Risk Management (Animal Health)

The international standards of the OIE are the preferred choice of sanitary measures for risk management with respect to Animal Health related issues. The application of these sanitary measures should be in accordance with the intentions in the standards (Welte, 2000; OIE, 2010). The OIE uses "option evaluation" to refer to the identification and selection of risk management measures (FAO, 2007). In the case of animal health protection goals, RM enables the country to balance the desire to minimize the likelihood or frequency of disease incursions and their consequences with obligations under the WTO for example. Examples of RM measures that may be applied include:

- Additional requirements such as maturation procedures may be placed on meat from countries where FMD vaccination is practised,
- Minimum treatment requirements may be established for meat products in line with the animal disease situation in the country of export for the management of avian influenza or classical swine fever (European Commission, 2009).

3.9.4. Risk Management LMO field trials

A confined field trial is defined as a small-scale experimental field trial of an LMO plant species performed under terms and conditions that mitigate impacts on the surrounding environment." Most field trials are limited to 1ha or less. Confined trials are conducted to collect data, either on agronomic performance of a GM variety or on its potential biosafety impacts. Such trials are conducted under conditions known to prevent transfer of pollen and seed thus preventing dissemination of transgenes into and within the environment. This is also important to prevent the persistence in the environment of the transgenic plant or its progeny, and to prevent introduction of the transgenic plant or plant products into the human food or livestock feed pathways. Confined trials can serve several purposes from the regulator's point of view including:

- Facilitating collection of agronomic and ecological data required to complete the environmental safety assessment of the LMO.
- Evaluation of the environmental fate of novel plant expressed proteins, particularly pest control proteins; and assessment of morphological characteristics that could signal any changes to agronomic impact.
- Building public confidence in the biosafety regulatory system by demonstrating the safe conduct of confined field trials, including the monitoring and enforcement of regulatory standards.

For farmers, confined field trials also provide opportunity to appreciate first-hand the potential risks and benefits that may be afforded by the cultivation the GM crops concerned. Risk Management strategies cover a range of activities including storage and transport of seeds, planting (including cleaning of equipment), reproductive isolation, and provisions for harvest or termination and post-harvest handling as shown in Figure 20.

The Role of Inspectors in Management of Field trials include:

- Inspection of Field trials and field trial sites

- Inspection of all records as outlined in Figure 20 to ensure compliance with conditions of the approval of the field trial.

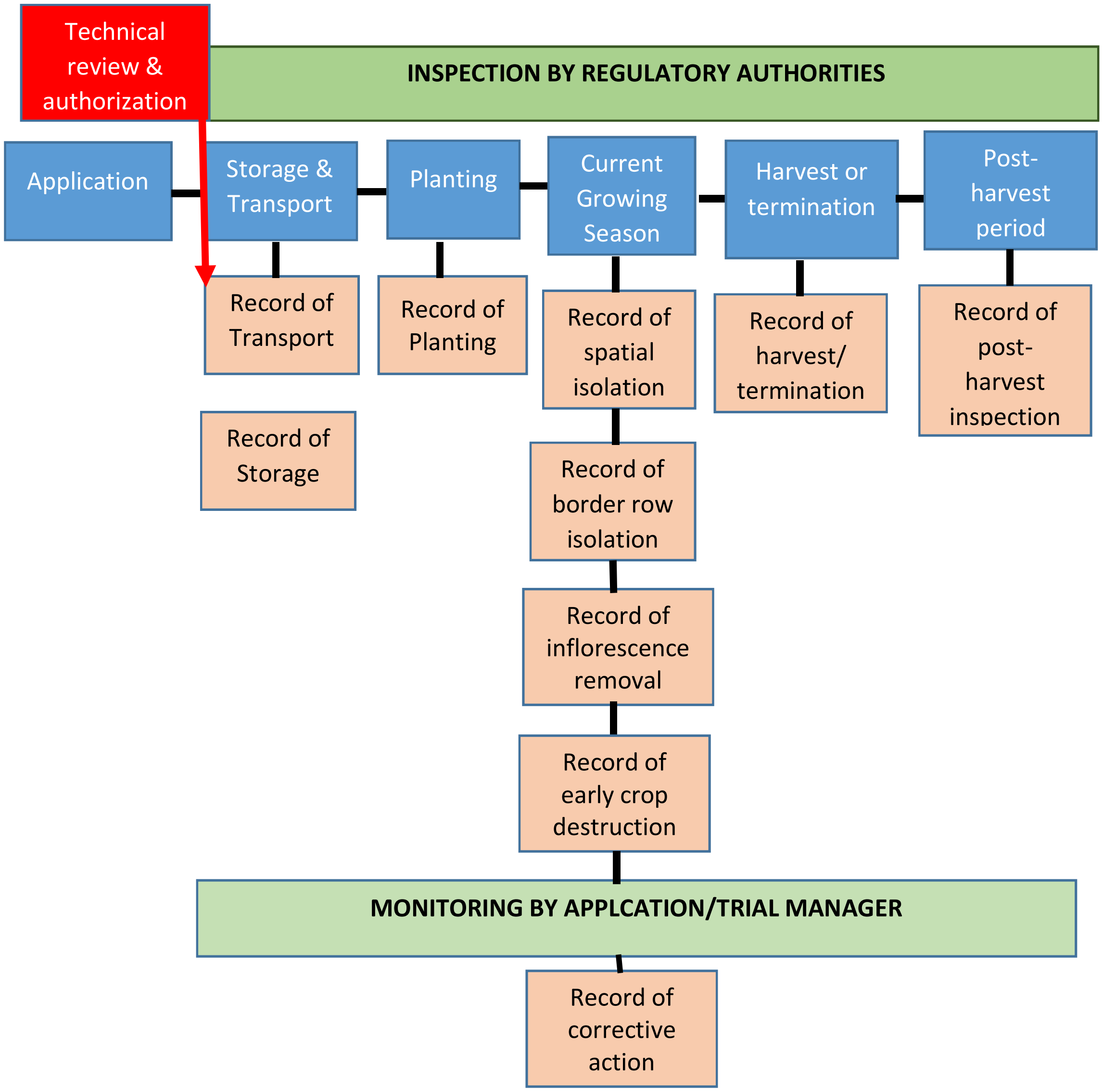

Figure 20: Oversight role of regulators in various activities related to risk management in confined trials

Source: CropLife 2005

Aspects that need to be inspected include:

- **Records for transport of regulated materials:** The movement of LMOs throughout all stages of operation in the facility must be controlled and logged. All records pertaining to this must be available.

- **Storage areas:** Storage areas in which LMOs are kept must be labelled, secure and separated from other materials. Access must also be strictly controlled. A record of the materials and quantities must be available.
- **Containment measures:** The isolation distances as outlined in the RM Plan must be adhered to.
- **Waste treatment and disposal:** All GMOs waste material must be rendered non-viable before disposal.
- **Training of personnel:** Staff working in contained use facilities must be trained on safe handling of LMOs. Records of training must be available.
- **Availability of guidance documents**: The facility must develop and keep an up to date repository of guidance documents including Standard Operating Procedures (SOPS).
- **Cleaning of vehicles and equipment**: Inspectors must ensure that all equipment is cleaned before and after planting LMO seed.

In the event of non-compliance, corrective action must be implemented and documented.

3.10. Risk Communication

Risk Communication should be continuous throughout the Risk Analysis process. This must be based on interactive exchange of information between regulatory authorities and stakeholders. Effective risk communication relies on robust communication strategies which aim at:

- Provision of general information on hazards and their management
- Standard setting processes
- Emergencies and how these are to be responded to
- International obligations including reporting (FAO, 2007).

Regulatory authorities have a number of obligations and responsibilities related risk communication. These include:

- Providing information on complex scientific issues in simple language and user-friendly format
- Engaging with all stakeholders including industry and civil society.
- Gathering concerns and perceptions of the public (FAO, 2007).

Key Points

- Risk analysis includes three components i.e. Risk Assessment, Risk Management and Risk Communication.
- Risk Analysis provides a basis for decision making in the context of:
    - Decisions on imports of potentially invasive non-native species, their vectors, or conveyances prior to establishment
    - Allocation of scarce resources towards higher risk threats
- Risk analysis in most biosecurity sectors follows a generic framework but differences exist in terms of terminology e.g. definitions of hazards, risk management measures etc.
- In phytosanitary applications, guidance is provided for by ISPM 11 (Pest Risk Analysis for Quarantine Pests) which also provides guidance for risk analysis of LMO plants as pests.
- IAS can have both direct and indirect consequences.
- Where import of a potential IAS is identified as a high risk, risk management measures (referred to using different terms in various biosecurity sectors) must be proposed.
- Risk communication is essential throughout the Risk Analysis.

End of module revision questions

QUESTION 1

Define Risk Analysis ____

____

QUESTION 2

Name the three components of Risk Analysis ____

____

QUESTION 3

Explain what is mean by hazard identification in Risk Analysis

____

____

QUESTION 4

In each of the cases below explain what is meant by the hazard:

i. Import risk analysis for terrestrial animals ______________________________________

____

ii. Import risk analysis for aquatic animals ____

____

iii. Pest risk analysis ____

____

iv. Environmental risk analysis of LMO plants ______________________________________

____

v. Environmental risk analysis of LMO animals _____________________________________

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vi. Ballast water management ____

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QUESTION 5

What factors must be considered in selection of risk management option?

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4. MODULE IV: TREATMENT OPTIONS

Purpose: To enable trainees to understand the range of treatment options available for control of various species groups as well as treatment options available for commodity groups.
Format: PowerPoint Presentations, Group discussion and Group activities.
Expected outcomes: By the end of the session, trainees will be able to describe treatment options to prevent entry of different invasive species by commodity type as well as by category of alien invasive species group.

ISPM No. 28 provides guidance for phytosanitary treatments. Phytosanitary treatments should meet the following requirements:

- They must be effective in killing, inactivating or removing pests, or rendering pests infertile or for devitalization associated with a regulated article.
- The efficacy must be stated with evidence to support that efficacy generated using appropriate scientific procedures,
- They must be feasible and applicable for use primarily in international trade or for other purposes, and;
- They must not be phytotoxic or have other adverse effects.

There are a number of treatment options that can be applied to minimise the risks quarantine pests.

4.1. Chemical Methods

Quarantine treatment options include chemical methods and non-chemical (physical methods). Chemical methods include fumigants, disinfectants etc. Physical methods include irradiation, dry heat, steam treatment and cold treatment.

4.1.1. Fumigation

A fumigant is chemical which, at a required temperature and pressure, is able to exist in the gaseous state at a concentration that is sufficient to be lethal to a given pest. Fumigants have the advantage of providing effective, economical control of pests sometimes even where other forms of pest control are not feasible. In many cases treatments can be carried out on infested material without disturbing it. Some advantages and limitations of fumigants include:

Advantages	Limitations
• Fumigants are wide spectrum pesticides and will thus kill all species and life stages of pests such as insects and rodents that are likely to be found in the structure being fumigated • Because of their gaseous state, fumigants penetrate into small spaces including nooks and crannies including the galleries of insects that infest interior wood which otherwise not be reached by other methods such as sprays and dusts. • The act rapidly without leaving a residue • Pests are rapidly killed and fumigant gas does not leave unsightly, odorous, or hazardous residues if the site is properly aerated after fumigation.	• Fumigants are broadly toxic and hazardous to use, and thus fumigations must be done by highly skilled and experienced personnel • Fumigants leave no protective residue thus pests may re-infest the fumigated site immediately after treatment • It requires properly enclosed spaces to be effective • It may be more costly than other methods

The choice of fumigant is guided by:

- The volatility and penetration power of the fumigant,
- The corrosiveness, odour, flammability, or explosive potential,
- Warning capabilities and detection methods,
- In the case of commodities, the fumigants' effect on seed germination and quality of the finished or processed product,
- Decomposition time of the fumigant chemical or its residues,
- Disposal of spent materials or containers,
- Availability of the product of choice, ease of application, and cost, and;
- Season of year, weather, and climate.

Other important considerations include:

- Pests to be controlled,
- Temperature (use at low temperatures discouraged),
- Moisture,
- Structure area fumigated, and;
- Method of application (University of Kentucky, undated).

The amount of fumigant required is calculated from the formula:

$$\text{Amount of fumigant (kg)} = \frac{Volume of Enclosure(m^3) \times Dosage(g/m^3)}{\%\ Fumigant Release \times 1000}$$

There are four fumigants that are generally used by NPPOs.

4.1.1.1. Methyl Bromide

Methyl bromide (Ch_3Br) is a colourless, non-flammable and gas. It has no odour except at high concentration. Methyl bromide is broad spectrum fumigant. It can be used against a wide variety of pests including spiders, mites, fungi, plants, insects, nematodes, rodents, snails and ticks and has also been reported to be effective against fungi and some plants. Methyl bromide can be used to treat commodities such as bulk grains, cereals, dried foods, wood packaging, wood, logs; perishable material including cut flowers, vegetables, fruit etc. It is generally well tolerated by plants although tolerance varies across species and also by stage of growth, condition etc.

Advantages of Methyl Bromide include:

- It has a good penetrating ability,
- It is fast acting,
- At the end treatment, the vapours dissipate rapidly making it safe to handle bulk commodities.

Limitations of its use include:

- It can accelerate decomposition in poor condition material,
- It can damage some plant products,
- It cannot penetrate through plastic, lacquered surfaces and paint,
- It may leave a residue on high oil content food such as nuts,
- It is not as effective as other fumigants,
- It is not suited for materials that contain sulphur (hair, fur, leather and rubber goods) due to an undesirable reaction with sulphur (University of Kentucky, undated).

Use of Methyl bromide is being reduced because it is listed as an ozone depleting substance under the Montreal Protocol. However, its use by NPPOs for Phytosanitary applications is exempt from this provision. Another consideration is the development of technologies to recapture the emissions of activated carbon from fumigation chambers. Cameroon has committed not to allow use of MeBr.

4.1.1.2. Ethylene dioxide

Ethylene oxide (CH_2OCH_2)is a colourless, toxic, flammable liquefied gas. It has an irritating, mustard-like odour (Cishawlaz, 2004). It is formulated with a carrier such as carbon dioxide or dichlorodifluoromethane to reduce flammability (University of Kentucky, undated). Ethylene oxide (ETO) is widely used by NPPOs for fumigation of dried plant products such as herbs and spices. It can also be used for black walnuts and copra (University of Kentucky, undated). It is lethal to live plants. Like Methyl bromide, it is a broad-spectrum fumigant.

> ETO has proved to be effective both under vacuum and at atmospheric pressure for destroying several species of snails entering the United States in military cargo from the Mediterranean area (Cishawlaz, 2004).

ETO has the advantage of being able to penetrate plastic packaging as well as painted and lacquered wood packaging. A major limitation is that it reacts strongly with living plant material and microorganisms and is thus not suitable for live material.

4.1.1.3. Phosphine

Phosphine (PH_3) is a highly toxic and deeply penetrating fumigant. It is used to treat pests in stored bulk grain. It is slow acting. Phosphine fumigants are sold in solid form, either as aluminium phosphide or magnesium phosphide.

Advantages

- The fumigant leaves minimal residues, and is acceptable to most markets
- It can be applied to bulk grain without the need to move the material

Limitations

- Slow rate of action. To kill all life stages of an insect pest, the material must be in contact with the fumigant for a minimum of 7 days.
- It leaks through holes in sheeting and walls
- Wind and large temperature changes accelerate phosphine loss.
- Most phosphine is lost within four days from fumigations in ordinary, unsealed storages
- Fumigation in unsealed containers will only kill some adults leaving the other life stage capable of continuing the life and breeding cycle

Based on Department of Agriculture and Fisheries https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/grain-storage/fumigation

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4.1.1.4. Sulfuryl Flouride

Sulfuryl fluoride (SO_2F_2) is a colourless, odourless gas. It is available as a liquid under pressure that volatilizes readily. It is non-corrosive and unreactive to most materials. It has good penetration to wood products but it needs fans or blowers to mix well with air as it is 3.5 times heavier than air. Sulfuryl fluoride is non-flammable, but in the presence of an open flame, it forms a very corrosive gas. The EPPO has developed a standard for use of Sulfuryl Flouride to treat dried fruit and nuts (EPPO, 2009).

4.1.2. Physical Methods

Physical treatment methods include irradiation, use of dry or wet heat and freezing.

- **Autoclaving:** This refers to the use of steam under pressure to sterilize material.
- **Freezing:** This involves subjecting the material to low temperatures, usually -18°C or lower to remove a risk.
- **Hot Water Treatment (Hydrothermal treatment):** This involves use of hot water to raise the temperature of the commodity, usually fruit that are hosts of fruit flies for a specified period of time (United States Department of Agriculture, Undated)
- **Steam pressure sterilization:** This involves introduction of steam into a sealed chamber in which the material to be treated has been placed. The pressure and temperature are maintained for an appropriate amount of time to ensure complete sterilization.

4.2. Treatment of hitchhiking organisms

This section is based on approved treatments of animal hitchhikers on commodities

The organism should be secured in a container e.g. a bag, cage, sack or box etc. which can be held in safe custody and which will aid the process of euthanasia**.** Table 22 shows treatments recommended for hitchhiker organisms.

Table 22: Methods for treating hitchhiking organisms

Organism type	Treatment
Amphibians, Reptiles and Fish	Place in a refrigerator for a period of 5 hr to induce torpor then in a freezer for 24 hr.
Small Mammals (e.g. rodents) and Birds	Concussion by a blunt instrument followed by decapitation may be used. Concussion as a method should be used only as the last resort
All organisms above	Injection with suitable barbiturates
All organisms above	Use of compressed Carbon monoxide recommended. Carbon monoxide has the advantage of being quick and painless. It can be applied for large numbers of animals e.g. if there is justification for elimination of many day old chicks. For amphibians and reptiles, the animal must be contained for 24 hours to ensure death as some species are capable of holding their breath.
Hitchhiker rodents sighted but not captured	Fumigation with Methyl Bromide at $4g/m^3$ for 5hrs at 10°C minimum and fan for first 20mins. Alternatively use Hydrogen cyanide $4g/m^3$ for 6 hrs at 4°C and above provided adsorption and penetration are not a concern
Rodent on an aircraft	Baiting programme must be implemented

Annex VIIIshows Treatments for various commodity groups/ commodities.

Key points

- ❖ Quarantine treatment options include chemical and non-chemical options.
- ❖ Examples of chemical treatments include fumigants and disinfectants.
- ❖ The most commonly used fumigants are methyl bromide, ethylene dioxide, phosphine and sulfuryl fluoride.
- ❖ Non-chemical (physical) methods include freezing, steaming, autoclaving and hot water treatment.
- ❖ Hitchhiking species can be treated

End of module revision questions

QUESTION 1

Name three criteria that phytosanitary treatments must meet

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____

____

QUESTION 2

State three advantages and limitations of ethidium bromide as a fumigant.

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____

____

QUESTION 3

Give three examples of physical means of treatment.

____

____

____

QUESTION 4

How would you treat each of the following?

Insect pests on dried fish for human consumption ______________________

____

Invertebrate pests on wood poles ______________________________

____

Feathers on artefacts ______________________________________

____

Fibre of animal origin ______________________________________

____

Wooden pellet infested with a fungus ___________________________

____

Dried vegetables infested with an insect _________________________

____

A hitchhiker lizard ____

QUESTION 5

Explain why Ethylene oxide is not suitable for use with living organisms

____

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5. MODULE V: TECHNICAL AND ADMINSTRATIVE ISSUES

Purpose: To enhance the understanding of the range of skills and supporting environment that is required to enhance the effectiveness of inspectors.

Expected outcomes: By the end of the session, trainees will be able to:

- Describe the roles and responsibilities of various stakeholders involved in inspection,
- Name core competencies required for their task,
- Demonstrate an understanding of supporting soft skills required in their roles
- Demonstrate an understanding of the importance of guidelines and procedures in implementing their task.
- Demonstrate an understanding of examination, validation and verification of documents accompanying good.
- Understanding various outcomes of inspection and the appropriate follow up actions.

Biosecurity inspection requires competence in key scientific areas as well as a number of soft skills to ensure effectiveness. Inspectors must be competent in the core area of the biosecurity sector they are concerned with be it animal safety, plant health, food safety, public health etc. Because of the large volume of goods and people in international traffic and a limited resource pool for inspectorates, sampling is an essential consideration.

5.1. Sampling of consignments for agricultural inspection

Sampling may be carried out for a number of reasons. Reasons for sampling as outlined in ISPM 31 include:

- Detecting regulated pests,
- Providing assurance that the number of regulated pests or infested units in a consignment does not exceed the specified tolerance level for the pest,
- Providing assurance of the general phytosanitary condition of a consignment,
- Detecting organisms for which a phytosanitary risk has not yet been determined,
- Optimizing the probability of detecting specific regulated pests,
- Maximizing the use of available inspection resources,
- Gathering other information such as for monitoring of a pathway,
- Verifying compliance with phytosanitary requirements , and
- Determination of the proportion of the consignment that is infested (IPPC Secretariat, 2009).

Sampling should follow internationally agreed protocols and be carried out by skilled personnel (IPPC, 2004[2]). Elements that need to be considered in determining sample size include:

- **Lot size:** This refers to a number of units of a single commodity identifiable by **homogeneity** in origin, grower, packing facility, variety, or degree of maturity, exporter, area of production, regulated pests and their characteristics, treatment at origin and type of processing.
- **Sample unit:** The appropriate unit for sampling will be determined by:
    - Homogeneity in the distribution of pests through the commodity,
    - Whether the pests are sedentary or mobile e.g. individual plant or plant product for low mobility pests; carton or other package type for higher mobility pests.
    - Packaging of the consignment
    - The intended use, etc. (ISPM, 2008).

5.1.1. Statistical sampling methods

Statistically based sampling is designed to detect a certain percentage or proportion of infestation with a specific confidence level. Use of statistically based methods require the NPPO to determine the following parameters:

- **The acceptance number:** The number of infested units or the number of individual pests that are permissible in a sample of a given size before phytosanitary action is taken. Most NPPOs use zero.
- **Tolerance level:** The status of infestation in the entire consignment.
- **Level of detection:** The minimum percentage or proportion of infestation that the sampling methodology will detect at the specified efficacy of detection and level of confidence. The level of detection may be specified for a pest, a group or category of pests, or for unspecified pests. The basis of this can be
    - Results of a pest risk analysis i.e. the infestation determined to present an unacceptable risk,
    - An evaluation of the effectiveness of phytosanitary measures applied before inspection, and;
    - An operationally based decision that inspection intensity above a certain level is not practical.

The Confidence level: This indicates the probability that a consignment with a degree of infestation exceeding the level of detection will be detected. Most NPPOs use a confidence level of 95%. A 95% confidence level means that the conclusions drawn from the results of sampling will detect a non-compliant consignment, on average, 95 times out of 100, and therefore, it may be assumed that, on average, 5% of non-compliant consignments will not be detected. The NPPO may choose to use different levels depending on the intended use.

Sampling may use statistically based methods or non-statistically based methods. Statistically based methods that may be applied in sampling include:

- **Random sampling:** The principle behind random sampling is that each sample unit has an equal and likely chance of being selected. It is applied when little is known about the distribution of the pest or even the rate of infestation. It is not optimal in cases where the pest is not uniformly distributed in the sample and may be more expensive than other methods. Use of the method may require random number tables.
- **Systematic sampling:** This involves drawing an initial sample randomly and thereafter drawing samples at fixed predetermined intervals from the lot. If the distribution of the pest in the lot coincides with the sampling interval this method may result in bias. Use of random tables may be required for the initial sample. Thereafter sampling may be automated.
- **Stratified sampling:** This involves subdividing the lot into strata and drawing sample units from each stratum using random or systematic sampling. The size of the sample drawn from each stratum may be different depending on the size of the subdivision and/or the extent of infestation between layers.
- **Sequential sampling:** In this case, a series of samples is drawn from the lot using any of the methods already described after which the accumulated data is compared with predetermined ranges and a decision is made on whether to accept or reject the consignment.
- **Cluster sampling:** Groups of units are selected based on a predefined cluster size e.g. boxes of fruit, bunches of flowers to make up the required sample size. It is best suited for when the pest is expected to be randomly distributed and also where the clusters are of the same size. Cluster sampling can be stratified and can also use systematic / random approach (IPPC Secretariat, 2008).
- **Fixed proportion sampling:** This involves taking a fixed proportion (i.e. a fixed percentage e.g. 2%) of the units in the lot. This method results in inconsistent levels of detection or confidence levels depending on the size of the lot.

5.1.2. Non-statistical sampling methods

Non-statistically based sampling methods include:

- **Haphazard sampling:** Units are drawn arbitrarily from the consignment. Whilst this may appear to be random, the inspector may be unconsciously biased hence the sample drawn may not be truly representative of the consignment.
- **Convenience sampling:** Samples are drawn from the lot based on convenience e.g. accessibility. No systematic selection criteria are applied.
- **Targeted or selective sampling:** In this method, the inspector deliberately selects samples from parts that are most likely to be infested or are obviously infested in order to increase the likelihood of detecting a pest.

5.1.3. Sampling from containers and trucks

For sampling from trucks and containers, Figure 21 shows some guidance based on International Seed Testing Association.

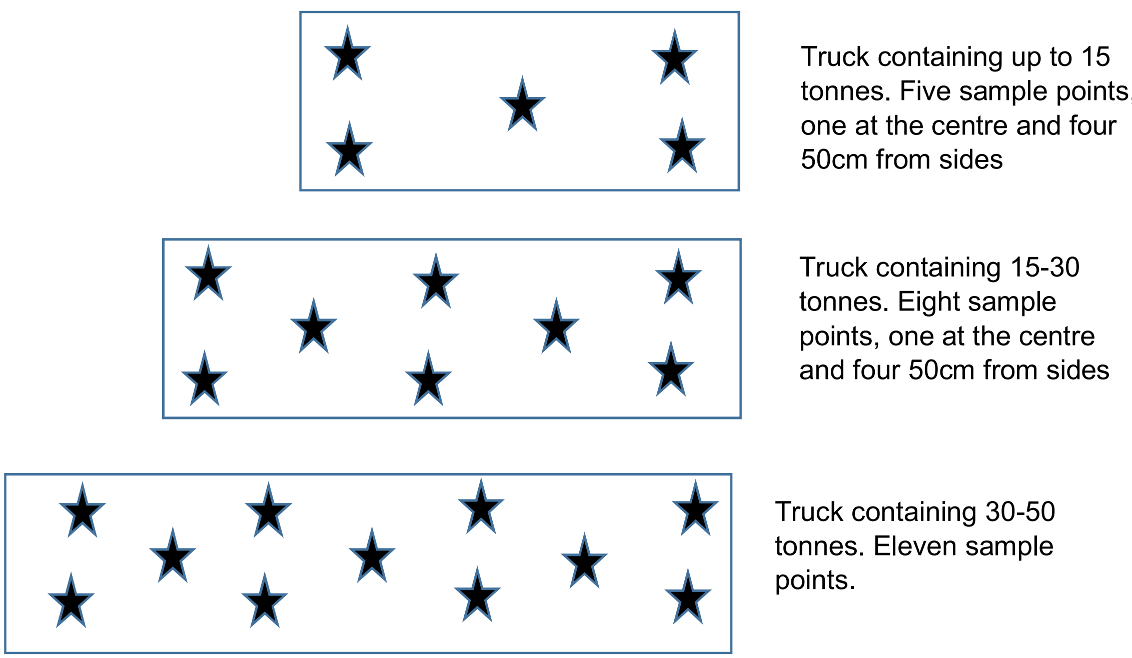

Figure 21: Methodology for drawing grain samples from trucks and bulk containers

From **http://www.fao.org/docrep/t1838e/T1838E0R.GIF**

Figure 22 shows probes that can be used to collect grain samples.

Figure 22: Probes used for sampling grain from trucks and bulk containers

(From http://www.canseedequip.com/grain-probes.php)

ANNEX IX shows sampling tables for various sampling methods and situations.

Sampling can never prove that a pest is truly absent hence inspection based on sampling can only demonstrate that the frequency of infestation is below a specified level or within a specified range, with a known level of confidence (EPPO, 2005). Some pests associated with both legal and illegal imports may still enter the country. This then underscores the importance of post-border monitoring and surveillance to ensure early identification of IAS. Figure 23 shows a generalised decision tree and also the how IAS may enter a country whether with legal or illegal imports.

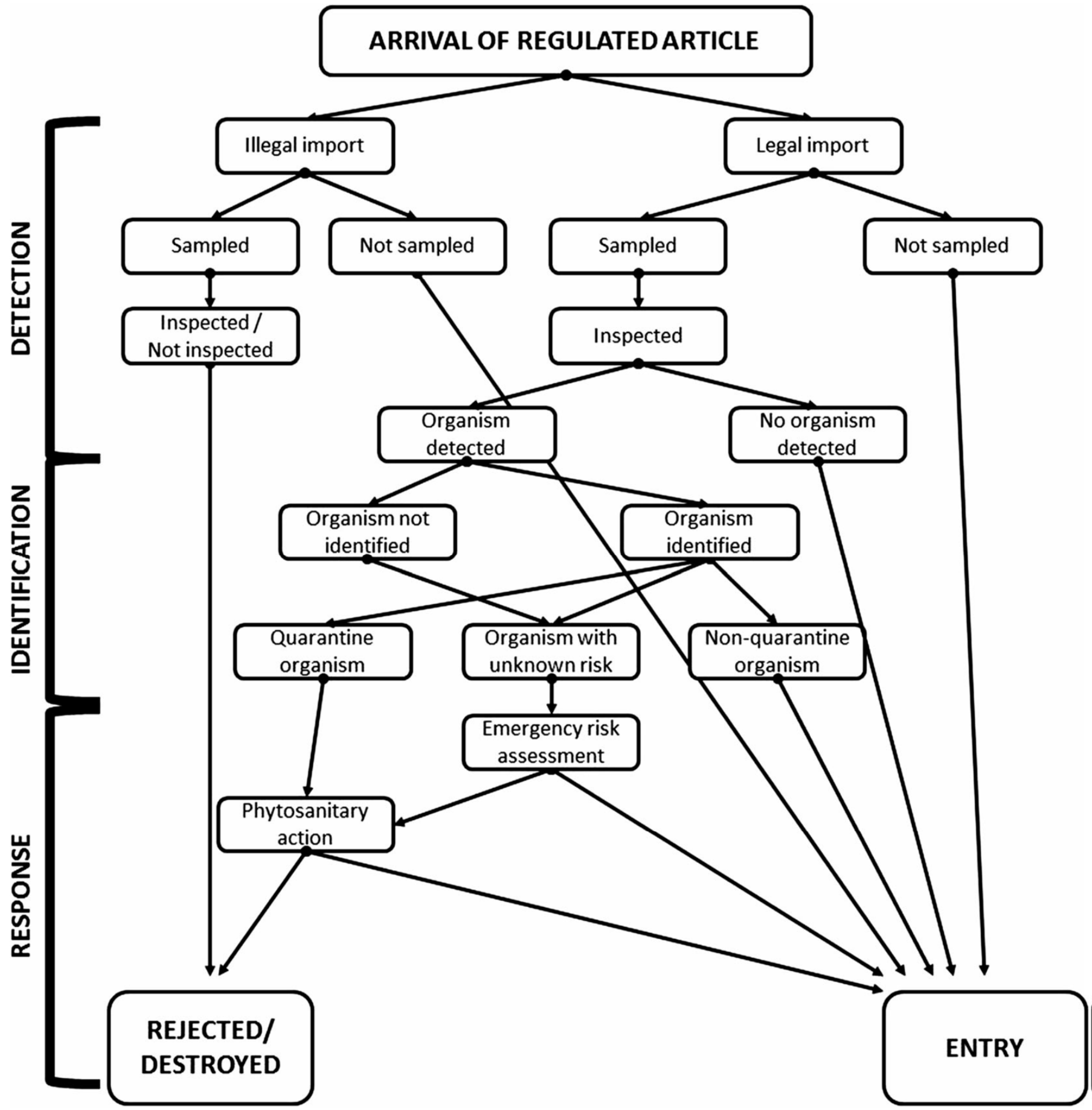

Figure 23: Generalised decision tree/ fate of IAS associated with legal or illegal imports

(From Saccagi *et al,* 2016)

5.2. Roles and responsibilities for inspection

Roles and responsibilities for vector control are summarised in Table 23.

Table 23: Roles and Responsibilities for Vector Control

Actor	**Responsibilities**
National Focal Point	• Establishment of the national regulatory framework in line with the IHRs • Establishment and maintenance of national cross-sectoral coordination mechanism and network of partner

	institutions/laboratories to assist in identification of vectors, reservoirs of infections and pathogens. • Supervise vector surveillance and control, • Transfer technical know-how and operational, and vector-control skills to all actors in vector control. • Ensure that vectors are controlled to a minimum distance of 400 metres from areas of PoE facilities that are used for operations involving travellers, conveyances, containers, cargo, and postal parcels, • Notifications as required by IHRs
National Competent Authorities	• Monitoring baggage, cargo, containers, conveyances, goods, postal parcels and human remains departing and arriving from affected areas, to ensure freedom from sources of infection or contamination, including vectors and reservoirs; • Maintenance of the sanitary condition of travel facilities and ensuring freedom from sources of infection or contamination, including vectors and reservoirs; • Supervision of deratting, disinfection, disinsection and decontamination of baggage, cargo, containers, conveyances, goods, postal parcels and human remains or sanitary measures for persons, as appropriate, • Liaise with conveyance operators, as far in advance as possible, of their intent to apply control measures to a conveyance, providing written information concerning methods to be employed;
PoE authorities or operators, conveyance operators, and service providers	• Conduct surveillance and apply public health measures to ensure vectors density remains below the **threshold level set by national policies and practices** • Screening of passengers o Inspection and validation of immunisation cards, o Administration of health declaration forms, o Reporting of passenger / flight attendant illness on board, o Maintenance of details of contacts of index cases,
Service providers involving travellers, conveyances, containers, cargo and, postal parcels	• Each service provider providing these services is responsible for vector control within the area their area of responsibility and ensuring that vector density remains below **the threshold level set by national policies and practices.** This may require spraying of craft as required by country of destination.
Health inspectors	• Inspection and verification of passenger health /immunisation cards • Screening of passengers • Filling and maintaining records of infected passengers • Inspection of means conveyance.

The roles and responsibilities for inspection must of necessity be viewed in the context of the biosecurity continuum and ideally within an integrated biosecurity system as opposed to the sector approach that is currently on the ground. An example of an integrated biosecurity system can be found in the United States where functions under Customs, Immigration and Quarantine Inspection were merged under the Customs and Border Protection Agency (CBPA), under the Border and Transportation Security (BTS) Directorate within the Department of Homeland Security to enhance coordination in security related issues. This means that border inspectors and customs officers must work closer together. This also has the benefit of minimising delays in processing consignments and the associated risks of economic loss especially in the context of perishable goods. Roles and responsibilities for inspection are shown in Table 24.

Table 24: Roles and responsibilities in the biosecurity continuum

ACTIVITIES	RESPONSIBILITIES
PRE-BORDER ACTIVITES	
Participation under international standard setting initiatives e.g. OIE, IPPC, WHO, International Civil Aviation Organization(ICAO) etc.	• MINSANTE • MINADER, Directorate Inspection • National Airports Authorities
Collaboration with trade partners for capacity building in pest, disease, LMO and vector control	• NPPO working closely with Ministry of Commerce • Biosafety regulators • Veterinary Inspectorate Services
Maintenance of VFZs at points of entry	• Ministry of Health working with Ports Authorities
Agreements with trade partners for recognition of Pest Free Areas, Disease Free Zones, off-shore treatment and in transit treatment of commodities.	• Ministry of Agriculture, Directorate Inspection • MINEPIA
Risk Analysis and permit systems prior to trade	• National Biosafety Committee / Competent Authority • Ministry of Agriculture, Directorate Inspection • Veterinary health regulators, • Food Safety regulators
Requirements for rodent free certificates for vessels	• Ministry of Public Health • National Ports Authority
Fumigation of aircraft prior to arrival	• Craft operators
Liaising with pilots and service providers on passengers who are ill and their contacts	• Airports Authorities • MINSANTE
Development and review of Ballast Water Management Strategies (BMWS)	• Ship operators • Sea Ports Authorities
BORDER ACTIVITIES	

Entry screening of passengers (Health declarations, vaccination cards and temperature scans)	• Health inspectors
Treatment and quarantine of infected passengers	• MINSANTE
Tracing of index cases and their contacts	• Airports Authorities • Airline operators • MINSANTE
Compliance checks on consignments of agricultural imports	• Phytosanitary Inspectors • Veterinary Inspectors • Food Safety Inspectors
Inspection of incoming mail and parcels	• Ministry of Post and Telecommunications (MINPOSTEL) • MINADER, Inspectorate • MINEPEA
Inspection of passengers and their goods	• Inspectors across all biosecurity sectors
Development and review of sampling strategies	• Inspectorates across all biosecurity sectors
Maintenance of inspection records	• Inspectors across all biosecurity sectors
Accreditation of specialist service providers e.g. fumigation specialists,	• Public Health Authorities • Ministry of Agriculture, Inspectorate
Treatment of consignments, packages etc.	• Phytosanitary Inspectors • Veterinary Inspectors • Food Safety Inspectors • Accredited service providers
Ballast Water Exchange operations	• Sea Port Inspectors • Ship crew
Sediments removal	• Ship crew • Sea Ports Inspectors
Ballast tank inspection	• Ship crew/ operators • Sea Port Inspectors • Public health inspectors
Ballast Water and Sediment sampling	• Sea Port Inspectors • Laboratories
Raising awareness on permitted and prohibited material and activities	• All biosecurity related authorities i.e. ○ National Biosafety Competent Authority ○ Food Safety Authorities ○ National Plant Protection Agencies ○ Animal Health Authorities
Liaison with stakeholder on compliance requirements for imports including how compliance will be assessed	All biosecurity related authorities
Development and management of compliance records	Inspectors across all biosecurity sectors
Preparing non-compliance reports	Inspectors across all biosecurity sectors

5.3. Requirements for inspectors

5.3.1. Legal mandate to carry out their duties

Inspectors must have mandate i.e. legal authority to carry out their duties provided for by legislation or other legal instrument. This includes for example, authority 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,
- Take and remove samples from imported commodities or other regulated articles, or from places where regulated pests may be present,
- Detain imported consignments or other regulated articles,
- Treat or require treatment of imported consignments, or other regulated articles including conveyances, or places or commodities in which a regulated pest may be present,
- Refuse entry of consignments, order their reshipment or destruction
- Take emergency action (IPPC Secretariat, 2004[2]).

These provisions are also true for inspectors in other biosecurity sectors.

5.3.2. Ability to take meticulous notes and keep records

Because of the potentially contentious nature of their work, and also because of its importance in informing planning and policy, inspectors must take meticulous notes and keep records. In terms of phytosanitary inspection, the Canadian Food Inspection Agency requires, at the least the following details

- Date and time of day,
- Address(es),
- Name(s),
- Weather conditions, if applicable,
- Transaction numbers,
- Lot numbers or other identifying marks,
- Phytosanitary certificate numbers,
- Nature of the commodities inspected (including scientific names where applicable),
- Type of packing material,
- Quantities, including number of units inspected,
- Origin of consignment,
- Pests found and samples taken (can be supported with photographs etc.),

- Treatments called for following inspection and procedures to ensure that treatments have been completed effectively,
- Arrangements for re-inspection, when necessary,
- Any other details considered necessary or pertinent.

5.3.3. Technical Knowledge and competency in pest identification or access to pest identification capability

Formulation of appropriate response measures requires accurate identification of the organisms concerned. Some of the organisms of quarantine importance are very difficult to identify. Inspectors must either have the ability to identify such organisms or have adequate access to pest identification capability. This may require cooperation with specialist institutions e.g. universities and private laboratories.

5.3.4. Access to appropriate inspection facilities, tools and equipment

Inspectors must have access to appropriate infrastructure and tools to allow them to carry out their function effectively. In terms of the inspection facility itself, the following based on (Maynard & Nowell, 2009) may be considered:

- Fully enclosed room with solid floor and walls,
- Ceiling must be made of an impervious material with sealed joints,
- Doors must be specialised, non-opening windows and sealed light fittings,
- Room must have sealed or screened vents,
- Water supply must be appropriately sealed,
- Water drainage and,
- Waste disposal: This must ensure that potential escape of IAS is prevented.
- Waste should ideally not be transported over long distances.
- Surfaces must allow easy decontamination.
- Contingency measures must be in place to cope with escapes.

Some considerations for the inspection facilities include are shown in Box 6.

BOX 6: Considerations for inspection facilities

Location sites for inspection facilities

- Ideally on appropriate terrain largely immune from natural disasters such as earthquakes.
- As close to the country entry point as possible to minimise movement of material and potential for escape.
- Isolated or far from suitable habitats/ hosts to reduce likelihood of establishment in the event of escape.

Minimum requirement for inspection facility

- Fully enclosed room with solid floor and walls.
- Ceiling must be made of an impervious material with sealed joints,
- Doors must be specialised, non-opening windows and sealed light fittings
- Room must have sealed or screened vents
- Water supply must be appropriately sealed
- Water drainage and
- Waste disposal: This must ensure that potential escape of IAS is prevented.
- Waste should ideally not be transported over long distances.
- Surfaces must allow easy decontamination.
- Contingency measures must be in place to cope with escapes

5.3.5. Technical competencies

In addition to adequate knowledge in their core area of expertise, inspectors must also have the following competencies:

- Pest detection and identification,
- Identification of plants, animals, microorganisms and their products.

5.3.6. Soft Skills

Some critical skills for inspectors include the following are shown in Table 25.

Table 25: Soft skills required for inspectors

Skill	Rationale
Communication skills	Inspectors must have good verbal and writing communication skills as they need to be able to effectively communicate with a broad range of stakeholders in biosecurity including passengers, other authorities etc.
Language skills	Inspectors must be able to communicate with clients in a language they understand. Inspectors must thus either be able to communicate in multiple languages or at least have access to translation services.

Dealing with clients	Inspectors must be able to deal with clients calmly yet firmly, following the set procedure for inspection.
Conflict management	Inspectors may be required to deal with difficult clients whilst carrying out their duties. This may lead to conflicts and inspectors must be able to manage these effectively.
Cultural sensitivity	Inspectors come into contact with a range of clients from different cultural backgrounds. They must be able to show sensitivity whilst firmly administering their duties.
Computer literacy	Inspectors often have to deal with a large amount of information. Computing skills are helpful in helping them access information and also in keeping records.
Report writing and record keeping	Inspectors need to be able keep meticulous records and develop well written reports. This is important both in terms of proving information for monitoring the effectiveness of prevention measures but also should issues develop later on inspection records may provide valuable information.
Taking legal statements	Inspectors may be required to take legal statements. They must thus have capacity to do this effectively.
Mentoring and training	Inspectors need to be able to familiarise new recruits entering the system. This skill would also be useful in facilitating sharing of experience across sectors
Public awareness raising / sensitizing	Inspectors often serve as the "face" of the biosecurity sector they represent and as such are an important link with the public. They must thus have a command of the legislation they are working with and must be able to communicate it effectively to the public to ensure awareness and compliance.

5.3.7. Guidelines and procedures

Many of the issues involved in biosecurity are technical and complex. Also, it is important that that the process is transparent and objective. It is thus important that inspectors have access to written guidelines including regulations, manuals, SOPs, pest data sheets etc. Operational procedures that reinforce isolation of the facility must be in place at all times. Also, procedures and instructions for all processes related to inspection must be clearly laid out and adhered to. These include:

- How to check the identity of goods and organisms,
- How to check the exterior of means of transport/ conveyances and containers for contamination,
- Procedures for examination of goods and organisms for contaminants, pests/ weeds and disease,

- Procedures for ensuring the independence, integrity, traceability and security of the samples, and;
- Procedures for recording and managing data etc.

5.4. Examination of documents accompanying goods

Import and export documents are examined to ensure that they are complete, consistent, accurate, valid and not fraudulent. Specific requirements by sector include:

5.4.1. Inspection of health certificates

- Health certificates are valid only if the vaccine or prophylaxis used has been approved by the WHO,
- They must be signed by clinicians, who are medical practitioners or other authorized health workers, supervising the administration of the vaccine or prophylaxis.
- They must bear the official stamp of the administering centre in addition to the signature of the clinician,
- They are invalid if they have any amendments, erasures or are incomplete,
- They must be completed in English or in French. Another language in addition to either English or French may also be used (WHO, 2008).

5.4.2. Inspection of documents accompanying phytosanitary consignments

Phytosanitary certificates are the main document associated with plant agricultural imports. Reasons for rejection of Phytosanitary certificates are shown in Table 26.

Table 26: Reasons for rejecting phytosanitary certificates

Invalid Certificates	Fraudulent certificates
• Illegible • Incomplete • Period of validity expired or not complied with • Inclusion of unauthorized alterations or erasures • Inclusion of conflicting or inconsistent information • Use of wording that not consistent with the model • Certificates herein certification of prohibited products • Non-certified copies.	• Not authorized by the NPPO, • Issued on forms not authorized by the issuing NPPO, • Issued by persons or organizations or other entities that are not authorized by NPPO, • Contain false or misleading information.

Based on IPPC Secretariat, 2001

5.5. Inspection outcomes

The inspection outcome will depend on the findings of the inspection i.e. on whether the consignment is compliant or non-compliant with import requirements. If the consignment is compliant, no further action is required and the consignment is released. In phytosanitary inspections, non-compliance includes cases where:

- A listed quarantine pest is detected in a commodity for which it is regulated,
- A listed RNQP is present in a consignment of plants for planting at a level above the set tolerance level for those plants,
- Evidence of failure to satisfy bilateral arrangements,
- Consignment fails to comply e.g. presence of undeclared commodities, soil or other contaminant,
- Invalid or missing documentation, and;
- Failure to meet in transit measures.

Rejection in the case of a phytosanitary inspection means that the consignment (or lot) from which the sample has been taken may be subjected to phytosanitary action. This can include:

- **Detention:** Goods may be detained where for example, more information is required with due care to avoid consignment contamination.
- **Sorting and reconfiguring**: The affected products may be removed by sorting and reconfiguring the consignment including repackaging if appropriate
- **Treatment:** This option can be taken by the NPPO when an efficacious treatment is available.
- **Destruction:** The consignment may be destroyed in cases where the NPPO considers the consignment cannot be otherwise handled.
- **Reshipment.** The non-complying consignment may be removed from the country by reshipping.
- **Prohibition:** ISPM 20 allows for prohibition only when no alternatives for pest risk management exist. In this case, a technical justification is necessary. There is an additional requirement that NPPOs make provision to assess equivalent, but less trade restrictive measures. Prohibition is only provided for in the case of quarantine pests. In the case of RNQPs, the requirement is that they are subject to established pest levels (IPPC, 2004).

In the case of aquatic animal imports, introduction of imports can be prohibited where:

- Inspection by an official designated by the Aquatic Animal Health Service shows the consignment to be affected by a listed disease of concern to the importing country,
- The consignment is not accompanied by a valid international aquatic animal health certificate conforming to the requirements of the importing country.

5.6. Recommendations

A. **Preparation of guidance documents and Standard Operating Procedures:** There currently exists gaps in terms of detailed guidance in a number of key areas. It is recommended that the following are developed with utmost urgency:
   - Manuals for cleaning vehicles and equipment with particular emphasis on imports of used vehicles and agricultural equipment.
   - Guidelines for inspection and monitoring of contained use facilities working with LMOs and record forms
   - Guidelines for inspection and monitoring trials involving LMO and record forms Guidelines for post-release monitoring and surveillance of LMOs. The Manual on Biosafety Risk Assessment and Risk Management for Cameroon (Koch, 2004) for these. For example, specific guidelines to translate the inspection actions before, during and after field trials as outlined in the Manual and the accompanying inspection forms need to be developed.
   - SOPs to cover the range of inspection related functions across biosecurity sectors.

B. **Elaboration of thresholds:** Tolerance levels for Adventitious Presence and Low Level Presence for Cameroon need to be agreed on and elaborated through a legal instrument.

C. **Clear elaboration of protection goals and acceptable levels of protection to enhance effectiveness of Risk Analysis:** Protection goals in all sectors and the desired levels of protection must be clearly elaborated to assist with Risk Analysis.

D. **Integration and/or coordination of biosecurity and enhancing collaboration with the Customs Directorate:** This could be done through establishment of a single entity to coordinate biosecurity as suggested in (MINEPDED, 2015[2]) and a single, comprehensive Biosecurity Act. An example of this approach is New Zealand's Biosecurity System.

END OF MODULE REVISION

QUESTION 1

Distinguish between statistical and non-statistical sampling methods.

QUESTION 2

Give three examples of statistical sampling methods

QUESTION 3

State five roles that inspectors should play in the prevention of biological invasions.

QUESTION 4

State two reasons for rejection of phytosanitary certificates with two examples for each.

QUESTION 5

State the outcomes of inspection including follow-up actions that can be taken.

6. POST-COURSE KNOWLEDGE EVALUATION

QUESTION 1 What percentage of introduced plant species can be expected to be invasive in the new environment?

i. No more than 5%
ii. 10%
iii. 20-50%
iv. All introduced plant species are invasive

QUESTION 2 Which of the following groups of taxa contain species that have been reported to be invasive?

A. Viruses, fungi and algae and mammals
B. Mosses, ferns, invertebrates and birds
C. Higher plants, fish, amphibians and reptiles and birds.
D. All the above

QUESTION 3 Human beings can and/or have introduced invasive alien species with all these pathways except

A. Tissue culture
B. Agriculture and horticulture
C. Accidental transport
D. Colonization of new areas

QUESTION 4 The WHO instrument that is aimed at Prevention, protection, control and provision of a health response to the international spread of diseases whilst Minimising restrictions on international traffic and trade is the:

A. World Health Report
B. Bulletin of the World Health Organization
C. World Epidemiological Record
D. International Health Regulations

QUESTION 5 Which of the following is not a standard setting body recognized by the WTO?

A. The Codex Alimentarius Commission

B. The International Union for Conservation of Nature
C. The International Plant Protection Convention
D. The World Organisation for Animal Health.

QUESTION 6 Match each institution to the instrument that it is responsible for using arrows:

WTO	Ballast Water Management (BWM) Convention.
Secretariat of the Convention on Biological Diversity	Terrestrial Code
International Maritime Organization	Cartagena Protocol on Biosafety
The World Organization for Animal Health	SPS Agreement

QUESTION 7 What is the tolerance for vectors in Vector Free Zones?

A. 0%
B. 0-2%
C. 2-5%
D. Less than 10%

COURSE EVALUATION FORM

Date of Training ___________________________________

Evaluation Scores

	I agree strongly (5)	**I agree (4)**	**I neither agree or disagree (3)**	**I disagree (2)**	**I strongly disagree (1)**
1. The range of topics covered was broad enough to enable a sound grasp of Invasive Alien Species, inspection systems and related issues					
2. I learnt new information on inspection systems and management of IAS.					
3. The organization and flow was good					
4. The content of the PowerPoint presentations was of good quality					
5. The discussions were interesting and added value to the proceedings					
6. The training manual will add value to the training					
7. The delivery of training material was good					
8. I was able to contribute ideas and perspectives from my experience					
9. The workshop facilitation was to a high quality and standard.					
10. My expectations were met					
11. Overall, I am satisfied with the workshop					

Please complete the following

My favourite part of the training was ____

My least favourite part of the training was ____

What topics do you think needed more emphasis?

____

____

Please share any comments/feedback/suggestions on the content, format or logistics of the training.

____

____

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ANNEX I: DEFINITION OF TERMS USED

Alien species: A species occurring outside its normal distribution (BCP Glossary).

Invasive Alien Species: Alien species which threaten ecosystems, habitats or other species. (BCP Glossary)

Biological diversity: Biological diversity: The variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which this includes diversity within species, between ecosystems. (CBP Glossary)

Biofouling: The accumulation of various aquatic organisms on ships' hulls (IMO).

Consignment: A quantity of plants, plant products and/or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots) [ISPM No. 5 Glossary of Phytosanitary Terms] '.

Ecosystem: A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (CBP Glossary).

Fumigant: A chemical compound used in its gaseous state as a pesticide or disinfectant.

Establishment: The process of a non-native species in a new habitat successfully producing viable offspring with the likelihood of continued survival.

Inspection: Official visual examination of plants, plant products or other regulated articles to determine if pests are present and/ or to determine compliance with phytosanitary regulation [IPPC Secretariat, 2016]

Introduction: The movement by human agency, indirect or direct, of an alien species outside of its natural range (past or present) [CBD]

Introduced Species: Any species accidentally or intentionally transported and released by humans into an area outside its present range.

Invasive Alien Species: An alien species whose introduction and/or spread threaten biological diversity (as well as human health).

Living modified organism: Any living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology.

Lot: A number of units of a single **commodity**, identifiable by its homogeneity of composition, origin etc., forming part of a **consignment** [FAO, 1990; IPPC Secretariat, 2016].

Modern biotechnology: The application of:

a. In vitro nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA) and direct injection of nucleic acid into cells or organelles, or

b. Fusion of cells beyond the taxonomic family,

that overcome natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection (SCBD, 2000).

P*athway:* Any means that allows the entry or spread of a pest IPPC,

An activity or process through which a species may be transferred to a new location where it could become invasive.

Pest: Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant product (IPPC in FAO 1997).

Pest risk analysis: The process of evaluating biological or other scientific and economic evidence to determine whether a pest should be regulated as well as the strength of any phytosanitary measures to be taken against it.

Phytosanitary measure: Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of pests.

PRA Area: The area in relation to which the pest risk analysis is conducted [ISPM 5,]

Propagules: A vegetative structure that can become detached from a plant and give rise to a new plant, e.g. a bud, sucker, or spore.

Quarantine: Official confinement of regulated articles for observation and research or for further inspection, testing and/or treatment [ISPM 5, 2007]

Quarantine pest: A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled [ISPM 5, 2007]

Regulated, non-quarantine pest: A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party [ISPM 5, 2007].

Risk: The combination of the *magnitude* of the consequences of a *hazard*, if it occurs, and the *likelihood* that the consequences will occur (where hazard = potential of an organism to cause harm to human health or the environment). Potential and level of exposure are essential for existence of risk (CBP Glossary).

Risk assessment/analysis: A measure of the probability of a hazard occurring and the extent of the resulting damage (CBP Glossary).

Species: A group of organisms having many characteristics in common and ranking below a genus. Organisms that reproduce sexually and belong to the same **species** interbreed and produce fertile offspring.

V*ector:* Any living or non-living carrier that transports living organisms intentionally or unintentionally (ICES, 2005) or,

The specific means by which an invasive species moves within a particular pathway.

ANNEX II: SAMPLE PRE-KNOWLEDGE ASSESSMENT TEST

1. A species that occurs in the area in which it evolved is called:
    A. An invasive species
    B. A natural species
    C. A native species
    D. An exotic species

2. Why might non-native species be brought into Cameroon?
    A. For medical use
    B. For Agriculture
    C. By accident
    D. All of the above

3. **What are the three stages to invasiveness**
    A. Arrive Survive Invade
    B. Arrive Survive Establish
    C. Arrive Compete Establish
    D. Arrive Invade Establish

4. All non-native, or exotic, plants are invasive.
    A. True
    B. False

5. Invasive plants are usually characterized by:
    A. Fast growth rates
    B. High rates of reproductive
    C. Rapid spread
    D. All of the above

6. Which of the following is not part of the objectives of the Convention on Biological Diversity
    A. Conservation of biological diversity
    B. Promoting trade
    C. Sustainable use
    D. Fair and equitable sharing of benefits

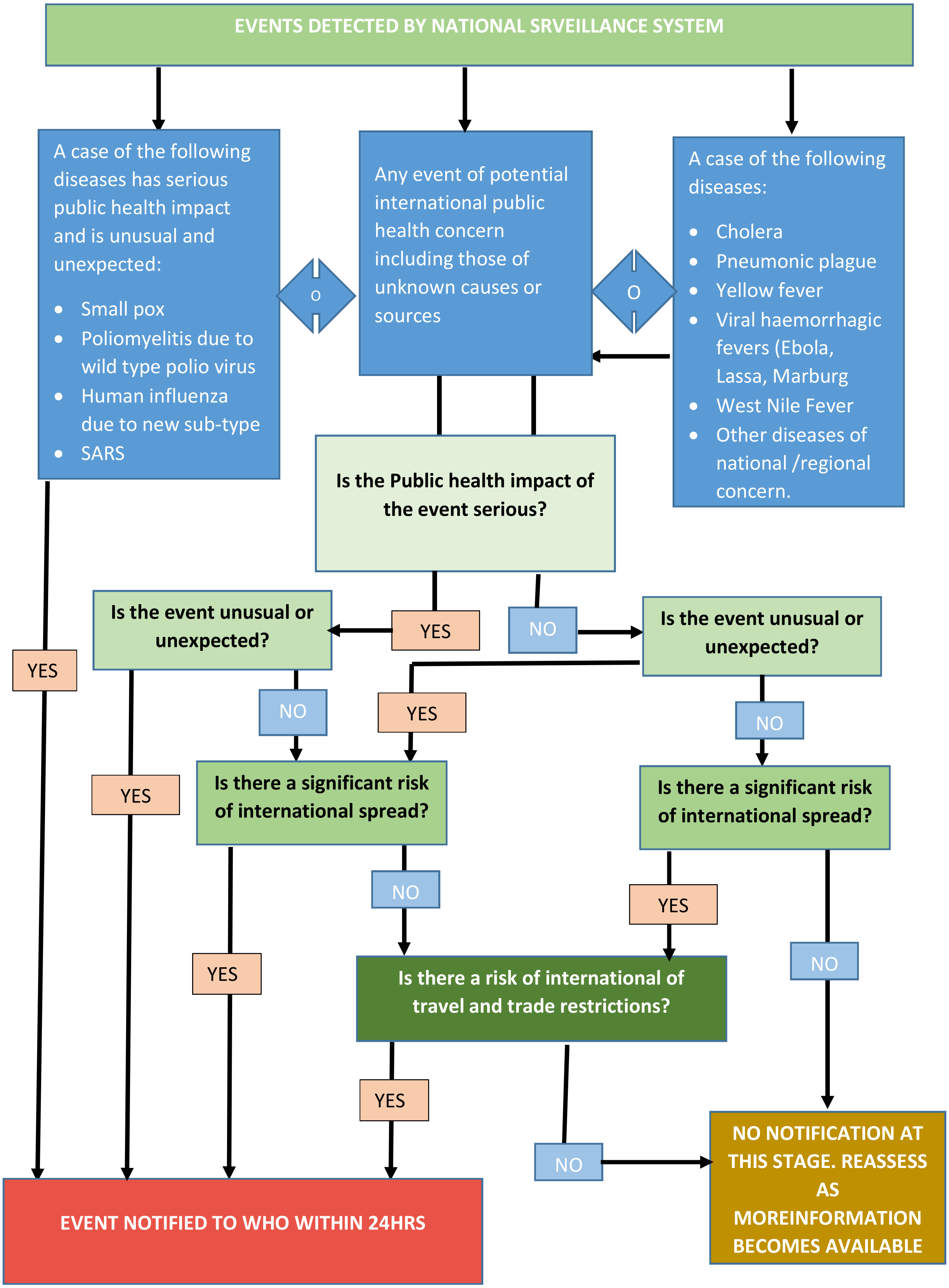
7. Which two extinction risks may be a direct result of the pet trade?
    A. Climate change and exotic species introduction
    B. Habitat loss and overharvesting
    C. Overharvesting and exotic species introduction
    D. Habitat loss and climate change

8. Certain plant and animal species cannot be brought into some countries to be sold as pets. What is the name of the international instrument that makes this illegal?
    A. Red List Migratory Bird Act
    B. Convention on International Trade in Endangered Species
    C. The Sanitary and Phytosanitary Agreement
    D.

9. Which of the following is not a stage in phytosanitary border inspection
    A. Examination of documentation
    B. Verification of consignment integrity
    C. Growing the sample for field observation
    D. Inspection of the consignment

10. Which of the following forms the basis for decision-making in many multi-lateral environmental Agreements**?**
    A. Public participation
    B. Stakeholder engagement
    C. Risk assessment
    D. Negotiation

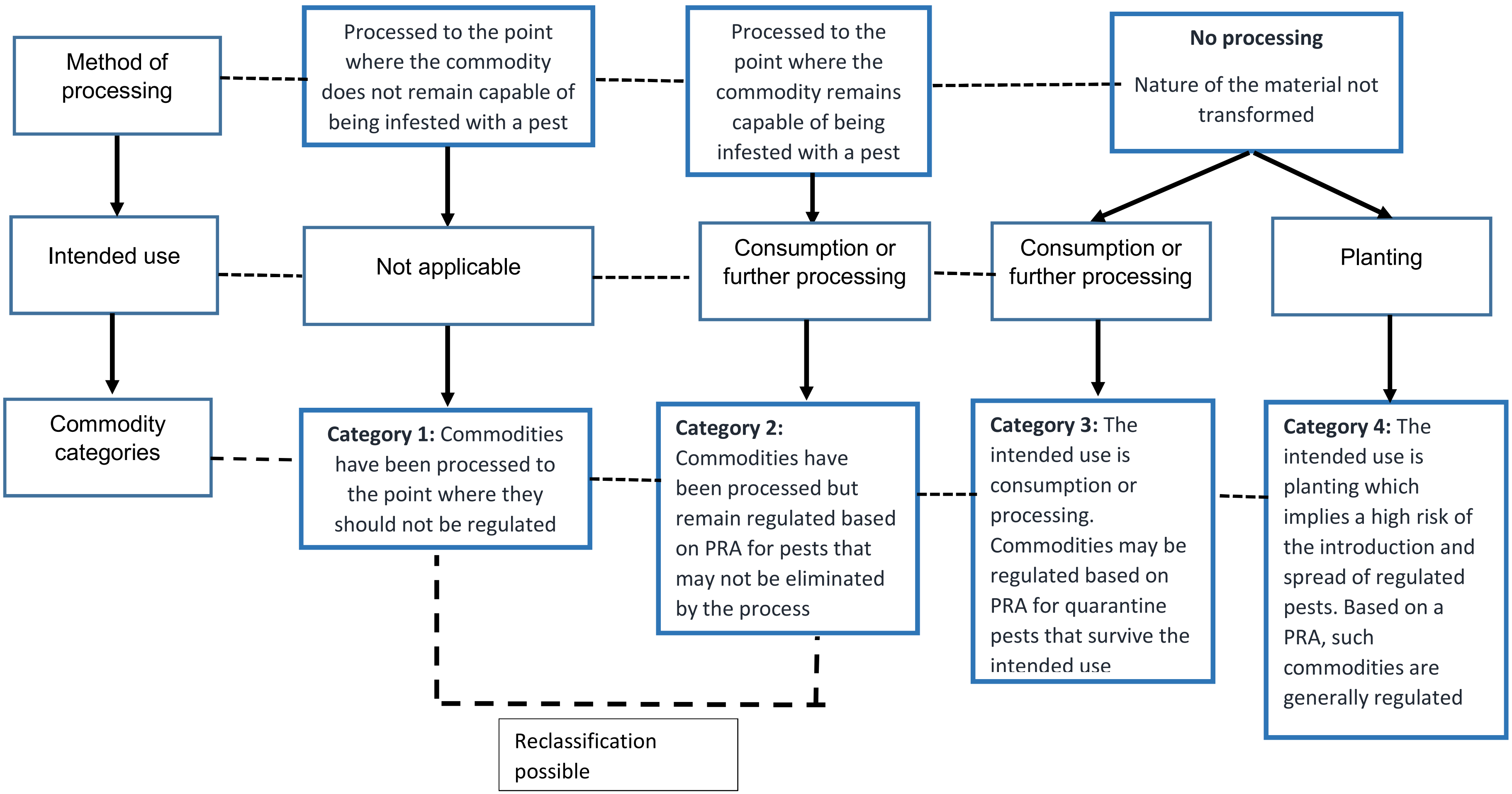
ANNEX III: WORLD HEALTH ORGANIZATION NOTIFICATION SYSTEM



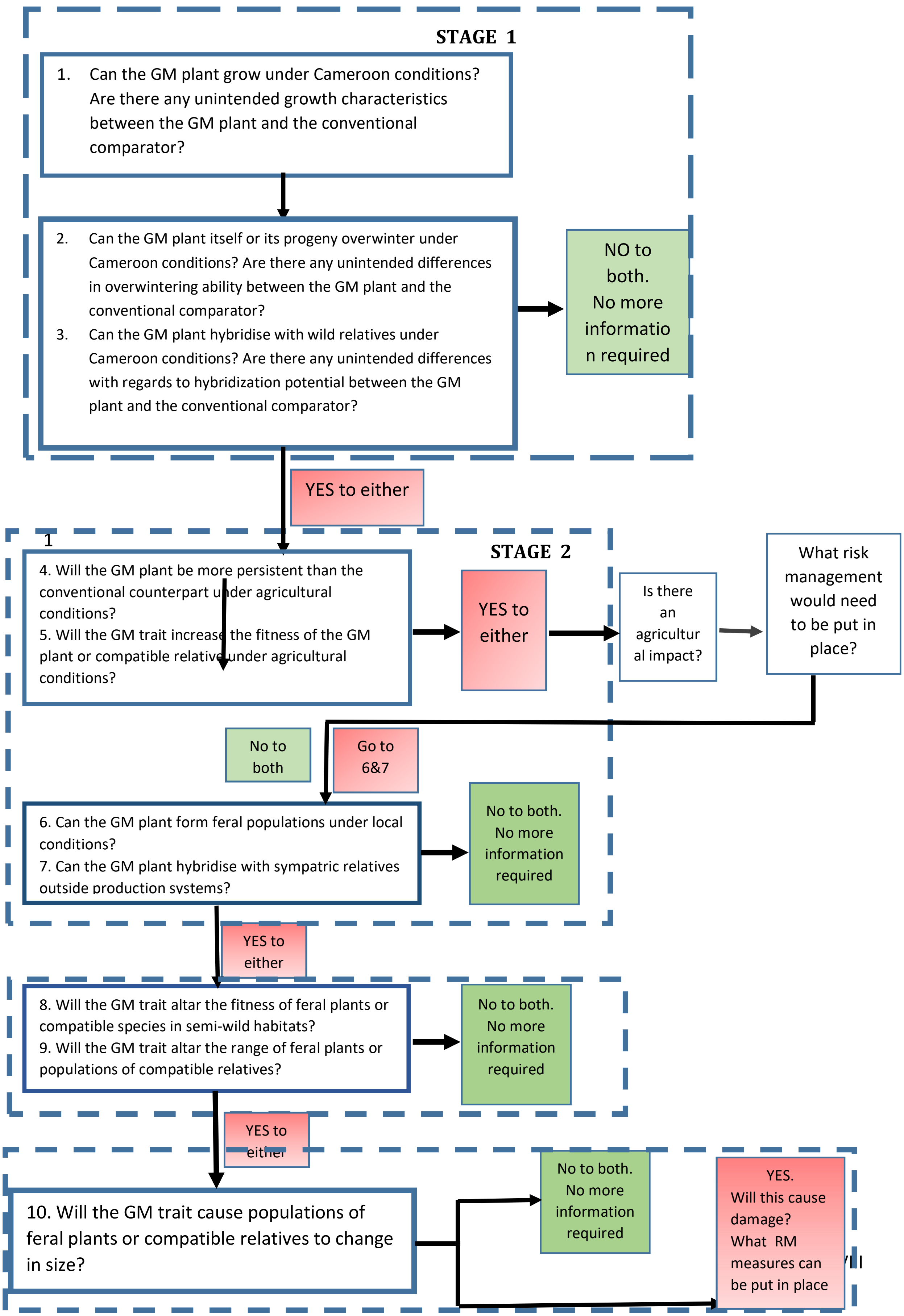
ANNEX IV: EQUIPMENT REQUIREMENTS FOR VECTOR SURVEILLANCE & MONITORING

CATEGORY	ITEMS
I. Furnishings	1. Adequate lighting 2. Air conditioning 3. Air curtains 4. Working desk 5. Paper/cork pin-up board 6. Comfortable revolving chair/stool 7. Iron racks for adult mosquito cages or desks 8. Storage cabinets 9. Insect cabinet
II. Equipment	1. Binocular dissecting microscope with spare parts (especially bulbs when equipped with internal light source) 2. Binocular compound microscope with spare parts (especially bulbs when equipped with internal light source) 3. Hand lens 4. Refrigerator 5. -20ºC deep freezer 6. CDC light traps or similar traps for mosquito surveillance with adequate spares 7. Desktop computer, printer, uninterrupted power supply with Internet connection 8. Photocopier 9. Laboratory thermometer and hygrometer 10. Rat traps (spring board, conventional iron cage, glue trap)
Chemicals and reagents	1. Immersion oil 2. Distrene-Plasticiser-Xylene (DPX), mountant 3. Para-dichlorobenzene 4. Sodium chloride (Nacl) 5. Giemsa stain (ready to use)
Glass ware, plastic ware, and minor instruments and materials	1. Petri plates 2. Glass slides 3. Cover slips 4. PCR tubes 5. Test tubes 6. Watch glasses 7. Tweezers 8. Dissecting needles

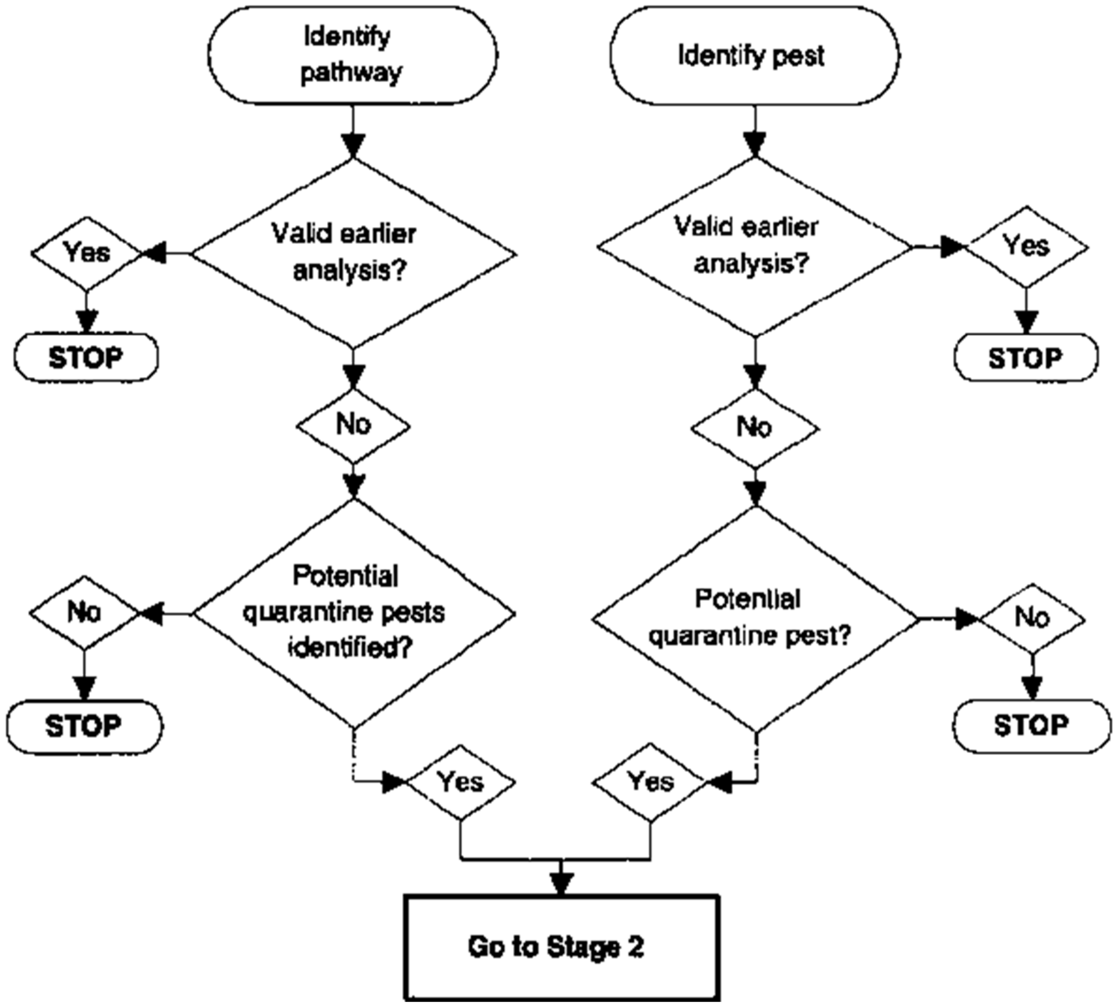
ANNEX V: FLOWCHART TO GUIDE DECISION-MAKING BASED ON DEGREE OF PROCESSING

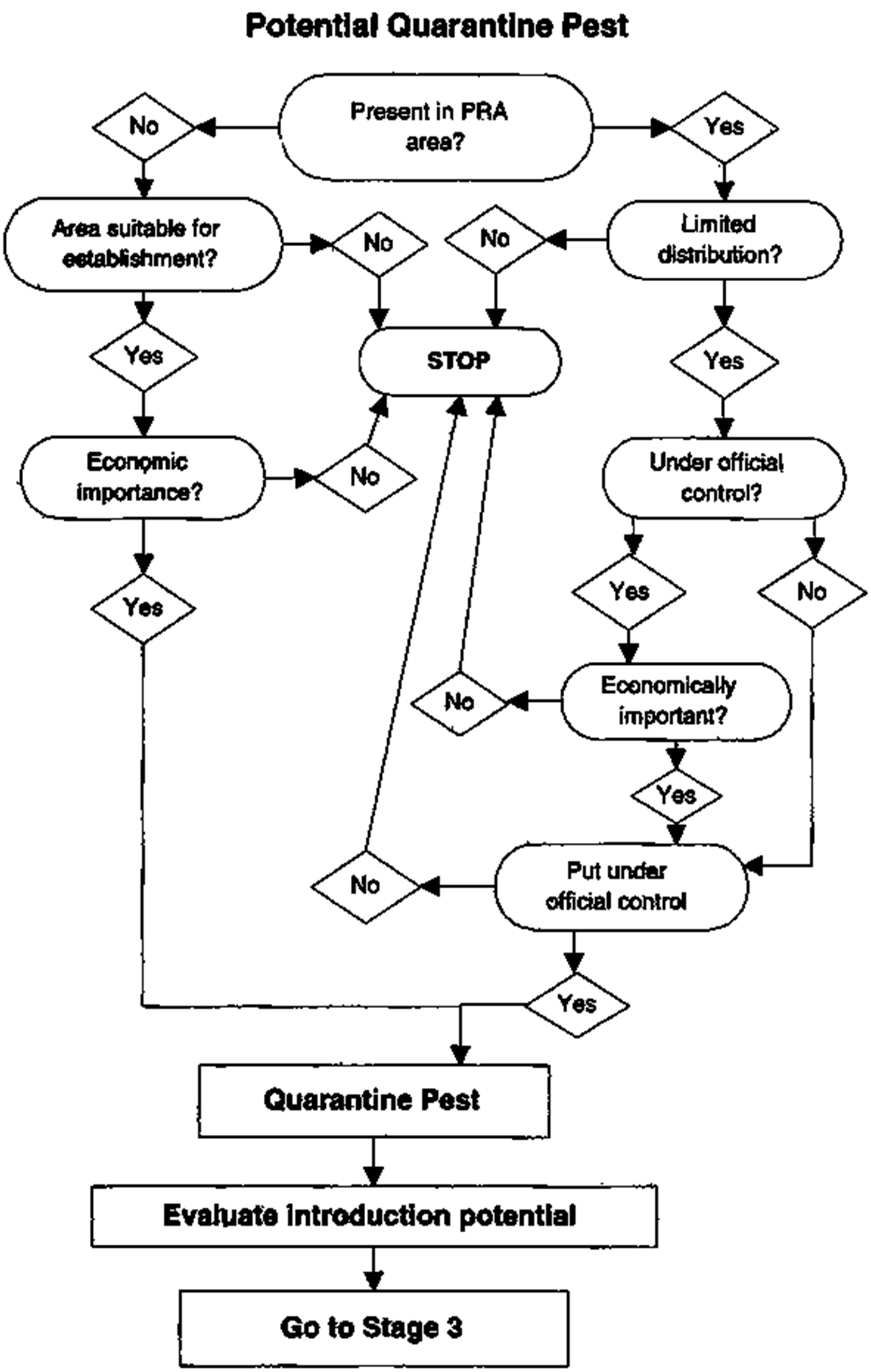


ANNEXVI: KEY QUESTIONS FOR RISK ANALYSIS OF LMOS



ANNEX VII: FLOW CHARTS FOR PRA





Source:
http://www.bioversityinternational.org/fileadmin/bioversity/publications/Web_version/300/ch2.htm

ANNEX VIII: QUARANTINE TREATMENTS USED FOR VAIOUS COMMODITIES

A. TREATMENTS FOR PRODUCTS OF ANIMAL ORIGIN

Commodity	Pest type	Treatment procedure	Comment
Animal Products and Non-Viable Dried Invertebrate Specimens (e.g. dead insect collections); Approved Animal Products for human consumption e.g. • Dried fish, • Milk powder, • Meat floss, stock cubes etc.	Insects and ticks	Fumigation with one of the following options: • MeBr at 64g/m^3 for 3 hrs at Vac: 91 kPa if at 10-15°C • MeBr at 56g/m^3 for 3 hrs at Vac: 91 kPa if at 16-20°C MeBr at 48g/m^3 for 3 hrs at Vac: 91 kPa if at 21-26°C; Fan circulation minimum 20 minutes at start of fumigation Or • Autoclave at 100 KPa Pressure for 30 min at 118^{o}C	Cameroon has committed not to use Methyl Bromide under her commitments in the Montreal Protocol.
	Mites	Fumigate twice with MeBr using one of the following options: • MeBr at 48g/m^3 for 3 hrs at Vac: 91 kPa if at 21-26°C; • MeBr at 56g/m^3 for 3 hrs at Vac: 91 kPa if at 16-20° C; or, • MeBr at 64g/m^3 for 3 hrs at Vac: 91 kPa if at 10-15°C The second fumigation must be 12-14 days after the first.	

Fibre from sheep, goats etc.		• Irradiation at a minimum dose of 50 kGy (i.e. either one treatment of 50 kGy, or two treatments of 25 kGy); or,
		• Destruction of the fibre by incineration or,
		• Removal of all seeds and plant material from the fibre AND any one of the following:
		  o Dying the fibre;
		  o Exposure to dry heat at 140°C for 3 hours;
		  o Immerse in water heated and maintained at 95°C for 25 minutes or 100°C for 15 minutes;
		  o Autoclave at 120°C for 10 minutes; or,
		  o Fumigate with 20ml/m^3 formalin for 8 hrs at Atm, 18°C, 80-90% humidity
			Treatment here is as necessary.

Ornamental animal products of animal origin including: • Skins, • Drums,		EITHER fumigation with: • 37% formalin at 20ml/m^3 and 16g potassium for 8 hrs at Atm, 18°C, 80-90% humidity; or; • 10% solution of formalin (formaldehyde solution) applied as spray in airtight container at 18°C for 8 hr	Items must be unpacked and cleaned of all contamination. Full exposure to formalin must be ensured.

• Game trophies, and • Blown eggs		For items over 32mm thickness add 1 hour per extra 4mm thickness • Irradiate at 50 kGy	
Feathers on handicrafts, artefacts, fly tying etc.		EITHER • Fumigation with 37% formalin at 20ml/m3 and 16g potassium for 8 hrs at Atm, 180 C, 80-90% humidity or, • Irradiation at 50 kGy	

B. QUARANTINE TREATMENT OF PRODUCTS OF PLANT ORIGIN

Commodity	Reason for treatment	Treatment	Pressure/ humidity	Dosage	Temperature (°C)	Duration of treatment	Comments
➢ **Woodware,** ➢ **Wood panels,** ➢ **Sawdust,** ➢ **Wood Chips,** ➢ **Wood Shavings and Wood Wool,** ➢ **Wood (up to 200 mm in thickness or cross-section);** ➢ **Other miscellaneous products e.g.** ○ **Pine/conifer cones,** ○ **Needles,** ○ **Twigs,** ○ **Smudge sticks etc.**	Invertebrate pests	MeBr	Atm	48gm^3 64g/m^3 80g/m^3	21 16-20 10-15	24Hrs	20 Min fan at start. Plastic containers perforated
			Vacuum	64 g/m^3	10 +	4 hrs	
		Phosphine	Atm	200ppm	10-15 16-20 21-25	15 Days 12 Days 9 Days	Top up needed due to sorption by wood
		Heat Treatment	Atm		56	At least 30 Min	Maintain 100% humidity for fragile products or wood prone to warping.
	Fungi, Extraneous organic material and Devitalisation	Heat Treatment			70°C	4 Hrs	Core temp must reach and be maintained at 70°C
		Autoclaving	100 kPa		120°C	10 Min	
		Incineration	Incinerate to ash at an approved facility				
	Fungi	Deep burial at an approved commercial landfill. Burial must be buried deep enough to allow a minimum of 2 metres land-fill coverage on the same day.					Risk items must be transported in risk-proof container
➢ **Wood packaging**	Compliance to ISPM 15 or, Invertebrate pests	Heat Treatment			56°C	30 Min	Core and entire surface must reach 56°C
		MeBr	Atm	48g/m^3 or 650C:T or 24 g/m^3	21+	24 hrs	20 minutes of fan at the start. Filleted or otherwise separate layers by at least every 200mm
		MeBr		56g/m^3 or 800 C:T or 28g/m^3	16-20	24 hrs	
		MeBr		56g/m^3 or 800 C:T or 28g/m^3	10-15	24 hrs	

➢ **Bamboo,** ➢ **Cane,** ➢ **Rattan,** ➢ **Willow and** ➢ **Bark (includes wood items containing bark, bark chips, cork, bark pencils)**	Insect pests	MeBr	Atm	48g/m³	26+	24 Hr	Fan circulation minimum 20 minutes at start of fumigation Plastic wrapping opened or perforated
				64g/m³	21-25		
				80g/m³	16-20		
				96g/m³	10-15		
			Vac	64 g/m³	10 +		
➢ **Poles,** ➢ **Piles,** ➢ **Rounds,** ➢ **Sleepers (including railway sleepers)** ➢ **Wood (greater than 200mm in thickness or cross-section)** ➢ **Wood fillets spaced more than 200mm apart**	Invertebrates	MeBr	Atm	160 g/m³	10-15+	48 hrs	
				120 g/m³	16+	48 hrs	
		Heat Treatment	Atm		56	30 Min	
	Invertebrates, Pathogens, Extraneous organic material	Heat Treatment	Atm		70	26 hrs	100% humidity to be maintained for fragile products or wood prone to warping
Bulk containerised stored products, 50kg plus i.e. ➢ **Dried vegetables** ➢ **Dried fruit,** ➢ **Grain,** ➢ **Seed,** ➢ **Nuts, etc.** **for human consumption, processing or stock food**	Insects except *Trogoderma* spp.	MeBr	Atm	48 g/m³	21+	24 hrs	Fan circulation minimum 20 minutes at start of fumigation.
				64g/m³	16-20		
				80g/m³	10-15		
		Phosphine	Atm	2 g/m³	10-15	15 days	A day can be subtracted from the duration if cylinder compressed /generated phosphine is used.
					16-20	12 days	
					21-25	9 days	
					26-35 (Max)	5 days	
		Freezing	Atm		-18°C or lower	7 days	
		Heat Treatment	Atm		56°C	30 Min	Core must reach and be maintained at 56°C

Stored products i.e. ➢ **Dried vegetables** ➢ **Dried fruit,** ➢ **Grain,** ➢ **Seed,** ➢ **Nuts, etc.** **for human consumption, processing or stock food**		MeBr	Atm	40g/m³ 56g/m³ 72g/m³ 96g/m³ 120g/m³	32+ 27-31 21-26 16-20 10-15	12Hrs	Fan circulation minimum 20 minutes at start of fumigation. High dosages may make products unacceptable for consumption.
		Heat Treatment			60+	30 Min	Core must reach and be maintained at 60°C

C. HEAT Treatment of Wood Products

Product type	Reason for treatment	Treatment		Wood thickness	Temperature	Duration of treatment	
➢ **Woodware,** ➢ **Wood panels,** ➢ **Sawdust,** ➢ **Wood Chips,** ➢ **Wood Shavings and Wood Wool,** ➢ **Wood (up to 200 mm in thickness or cross-section);** ➢ **Other miscellaneous products e.g.** ○ **Pine/conifer cones,** ○ **Needles,** ○ **Twigs,** **Smudge sticks etc.**	Pathogens (including fungi), Extraneous organic material (e.g. leaves, twigs, soil), Devitalisation (e.g. unprocessed burls)			0-25 mm	70	4 hrs	MPI Unprocessed burls and potentially viable materials, in particular, must be rendered nonviable (devitalisation) Note: maintain 100% humidity for fragile products or wood prone to warping.
				25-38 mm		5 hrs	
				38-50 mm		6hrs	
				50-75mm		8hrs	
				75-100 mm		10 hrs	
				100-150mm		14 hrs	
				150-200mm		18hrs	
				200-250mm		22 hrs	
				250mm+		26 hrs	

ANNEX IX SAMPLING TABLES

Table 1: Table of minimum sample sizes for 95% and 99% confidence levels at varying levels of detection according to lot size, hypergeometric distribution

Number of units in consignment	**P = 95% (confidence level) x % level of infestation**					**P = 99% (confidence level) x % level of infestation**				
	5	2	1	0.5	0.5	5	2	1	0.5	0.1
25	23	-	-	-	-	25	-	-	-	-
50	35	48	-	-	-	42	50	-	-	-
100	45	78	95	-	-	59	90	99	-	-
200	51	105	155	190	-	73	136	180	198	-
300	54	117	189	285*	-	78	160	235	297*	-
400	55	124	211	311	-	81	174	273	360	-
500	56	129	225	349*	-	83	183	300	421*	-
600	56	132	235	379	-	84	190	321	470	-
700	57	134	243	442*	-	85	195	336	548*	-
800	57	136	249	420	-	85	199	349	546	-
900	57	137	254	474*	-	86	202	359	614*	-
1 000	57	138	258	450	950	86	204	368	601	990
2 000	58	143	277	517	1553	88	216	410	737	1800
3 000	58	145	284	542	1895	89	220	425	792	2353
4 000	58	146	288	556	2108	89	222	433	821	2735
5 000	59	147	290	564	2253	89	223	438	840	3009
6 000	59	147	291	569	2358	90	224	442	852	3214
7 000	59	147	292	573	2437	90	225	444	861	3373
8 000	59	147	293	576	2498	90	225	446	868	3500
9 000	59	148	294	579	2548	90	226	447	874	3604
10 000	59	148	294	581	2588	90	226	448	878	3689
20 000	59	148	296	589	2781	90	227	453	898	4112
30 000	59	148	297	592	2850	90	228	455	905	4268
40 000	59	149	297	594	2885	90	228	456	909	4348
50 000	59	149	298	595	2907	90	228	457	911	4398
60 000	59	149	298	595	2921	90	228	457	912	4431
70 000	59	149	298	596	2932	90	228	457	913	4455
80 000	59	149	298	596	2939	90	228	457	914	4473
90 000	59	149	298	596	2945	90	228	458	915	4488
100 000	59	149	298	596	2950	90	228	458	915	4499
200 000	59	149	298	597	2972	90	228	458	917	4551

Table 2: Table of sample sizes for 80% and 90% confidence levels at varying levels of detection according to lot size, hypergeometric distribution

Number of units in lot	P = 80% (confidence level) % level of detection × efficacy of detection					P = 90% (confidence level) % level of detection × efficacy of detection				
	5	2	1	0.5	0.1	5	2	1	0.5	0.1
100	27	56	80	-	-	37	69	90	-	-
200	30	66	111	160	-	41	87	137	180	-
300	30	70	125	240*	-	42	95	161	270*	-
400	31	73	133	221	-	43	100	175	274	-
500	31	74	138	277*	-	43	102	184	342*	-
600	31	75	141	249	-	44	104	191	321	-
700	31	76	144	291	-	44	106	196	375*	-
800	31	76	146	265	-	44	107	200	350	-
900	31	77	147	298*	-	44	108	203	394*	-
1000	31	77	148	275	800	44	108	205	369	900
2000	32	79	154	297	1106	45	111	217	411	1368
3000	32	79	156	305	1246	45	112	221	426	1607
4000	32	79	157	309	1325	45	113	223	434	1750
5000	32	80	158	311	1376	45	113	224	439	1845
6000	32	80	159	313	1412	45	113	225	443	1912
7000	32	80	159	314	1438	45	114	226	445	1962
8000	32	80	159	315	1458	45	114	226	447	2000
9000	32	80	159	316	1474	45	114	227	448	2031
10 000	32	80	159	316	1486	45	114	227	449	2056
20 000	32	80	160	319	1546	45	114	228	455	2114
30 000	32	80	160	320	1567	45	114	229	456	2216
40 000	32	80	160	320	1577	45	114	229	457	2237
50 000	32	80	160	321	1584	45	114	229	458	2250
60 000	32	80	160	321	1588	45	114	229	458	2258
70 000	32	80	160	321	1591	45	114	229	458	2265
80 000	32	80	160	321	1593	45	114	229	459	2269
90 000	32	80	160	321	1595	45	114	229	459	2273
100 000	32	80	160	321	1596	45	114	229	459	2276
200 000	32	80	160	321	1603	45	114	229	459	2289

How to use the Tables.

1. Determine the confidence level to use. This is usually guided by national protection goals. Most NPPOs use a confidence level of 95%. This means the NPPO will detect a non-compliant consignment 95% of the time. This means the NPPO accepts the risk that 5% of the time, non-compliant consignments will not be detected.
2. Determine the number of units in the consignment.
3. Locate this value on the left hand side of the sampling table.
4. On the top row, locate the level of infestation to be applied as guided, for example by the Risk Assessment (0.5-5%).
5. Select the sample size that corresponds to the size of the lot and the level of infestation.
6. If the number of units does not appear on the Table, select the next bigger number.

Table 3: Table of sample sizes for 95% and 99% confidence levels at varying levels of detection, according to efficacy values where lot size is large and sufficiently mixed, binomial distribution

% efficacy	P = 95% (confidence level) % level of detection					P = 99% (confidence level) % level of detection				
	5	2	1	0.5	0.1	5	2	1	0.5	0.1
100	59	149	299	598	2995	90	228	459	919	4603
99	60	150	302	604	3025	91	231	463	929	4650
95	62	157	314	630	3152	95	241	483	968	4846
90	66	165	332	665	3328	101	254	510	1022	5115
85	69	175	351	704	3523	107	269	540	1082	5416
80	74	186	373	748	3744	113	286	574	1149	5755
75	79	199	398	798	3993	121	306	612	1226	6138
50	119	299	598	1197	5990	182	459	919	1840	9209
25	239	598	1197	2396	11982	367	919	1840	3682	18419
10	598	1497	2995	5990	29956	919	2301	4603	9209	46050

Table 4: Sampling for products in bags

Number of bags	Number of primary samples
1 - 14	One sample from each bag
15 - 19	15
20 - 21	16
22 - 27	17
28 - 35	18
36 - 37	19
38 - 46	20
47 - 56	21
57 - 66	22
67 - 77	23
78 - 105	24
106 - 136	25
137 - 187	26
188 - 299	27
300 - 799	28
800 - 999	29
<1000	30