

Building an Effective Biosafety Regulatory System: The Nuts and Bolts

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Abstract

Activities with genetically modified organisms (GMOs) are subject to regulation in most countries. Nevertheless, many low income countries are in the early stages of establishing or implementing biosafety regulation. Whereas the importance of risk assessment in regulatory decision-making is well recognised and supported by guidance material and training courses, little guidance is available for other components that are necessary for a functional regulatory system. This review describes the key components common to most well-established regulatory systems and also provides some consideration on streamlining the structure and procedures for each component. It also describes some simple, commonly used tools, with examples, that may assist in the design and/or function of these regulatory components. Integrating these key components and applying the various regulatory tools can provide the basis for establishing an efficient and effective regulatory system for low income countries.

Keywords: biosafety, decision-making, genetically modified organisms, regulatory system, tools.

Riassunto

Le attività con gli organismi geneticamente modificati (OGM) sono soggette a regolamentazione nella maggior parte dei Paesi. Tuttavia, molti Paesi a basso reddito sono ancora nelle prime fasi di creazione o di attuazione delle norme sulla biosicurezza.

Nel processo decisionale normativo l'importanza della valutazione del rischio è ben nota e supportata da materiale di orientamento e corsi di formazione, poche sono invece le indicazioni disponibili sugli altri componenti necessari per un valido sistema di regolamentazione. Questo

articolo descrive componenti chiave che sono comuni nella maggior parte dei sistemi normativi più consolidati, e fornisce qualche considerazione sulla razionalizzazione della struttura e sulle procedure di ogni componente. Esso descrive inoltre alcuni semplici strumenti di uso comune, con esempi che possono aiutare nella progettazione e/o funzionamento di tali componenti, la cui integrazione insieme all'applicazione dei diversi strumenti normativi, può fornire la base per la creazione di un sistema normativo efficiente ed efficace per i Paesi a basso reddito.

1. INTRODUCTION

Advances in science and technology offer new products, new solutions. But these come with new concerns, new issues. Regulation is used to address this dilemma: providing protection from potential harms while allowing the market place to test potential benefits. For example, the products of modern biotechnology, in particular genetically modified organisms (GMOs), have been subjected to close regulatory scrutiny.

However, many countries are still in the early stages of developing or implementing a regulatory system for GMOs. Most are low income countries, which are further constrained by limited resources and expertise. This review considers the key elements that are crucial to building an effective, efficient biosafety regulatory system; one that is adaptable to the needs and capacity of low income countries.

1.1. Regulatory decision-making

Regulation uses a legal framework to make decisions. In the case of regulating GMOs, decisions concern authorising activities with, or uses of, GMOs such that the health of people and the environment are protected. Regulatory authorities commonly use risk assessment as the foundation for their decisions. Indeed, the literature is replete with examples of guidance on risk assessment methodology and many training courses in risk assessment of GMOs are available. However, all the other components (the “nuts and bolts”) required to establish a fully operational regulatory system have received far less attention. These components include:

- a policy framework that establishes and informs regulatory decision-making,
- legal requirements,
- administrative procedures for lodging, processing and storing information related to applications,
- evaluation of applications,
- communication and consultation with stakeholders and citizens throughout the decision-making process,
- processes to arrive at sound decisions, including conditions imposed on authorisations,
- procedures to monitor for compliance with conditions of an authorisation,

- capacity for compliance and investigation of possible breaches of approval conditions,
- capacity to check and review processes.

These components may be considered as self-evident to jurisdictions with well-established regulatory systems. However, this may not be the case for many low income countries that are still in the early stages of establishing biosafety regulatory systems. In addition, many of the local biosafety experts (e.g. researchers) involved in advising on these early stages may have little familiarity with the internal complexities of a functioning regulatory system. Furthermore, there is little readily available guidance on the basic building blocks to construct a biosafety regulatory system de novo. This is due, in part, to requirements that are specific to each jurisdiction.

Nevertheless, most established biosafety regulatory systems have all of the components listed above. By analogy, although each house may be designed to the unique specifications of the owner, most of the essential types of room (e.g. bathroom, bedroom, kitchen, living room) remain common to each design. Similarly, the listed regulatory components have related functions and considerations across most jurisdictions, but are adapted to the local specifications and available resources.

This review describes each of these basic regulatory components in greater detail. In addition, some consideration is provided on streamlining the structure and procedures for each component. Finally, some simple, commonly used tools, with examples, are described that may assist in the design and/or function of these regulatory components.

2. REGULATORY COMPONENTS

2.1. Policies

Policy is set by government and is expressed through legislation and other legal instruments. Policies outline the intentions and values of the government. Regulatory authorities are subject to these policies. These policies may include a government’s position on GMOs, the scope and functions of the regulatory authority, and the role of stakeholders, including other government departments and agencies.

Nevertheless, regulatory authorities may issue operational policies that assist the authority to fulfil its legislated functions. These operational policies may include; an operational course of action, a set of rules, or interpretation of legislation.

Scientific definitions may also be subject to policy directives. For example, does “biological organism” include a plasmid or a replication defective virus vector? Similarly, does “genetically modified (GM) organism” include synthetic organisms, directed point mutations, progeny of a non-GM scion attached to GM rootstock or somatic mutations? Interpretation of these terms can vary between jurisdictions, potentially affecting which organisms are subject to regulation.

In risk assessment, policy provides the scope and boundaries for identifying risk. For example, protection of the environment may or may not include consideration of social amenities, economic well-being, or culturally-important locations and places. Therefore risks to these components may or may not be considered in the risk assessment.

Policy also plays a key role in establishing what is considered an adverse effect/harm when postulating a risk scenario. Harm is not a scientific fact, but a subjective (value) judgment that can vary between people and circumstances. For example, a non-cultivated plant growing in an agricultural field may have adverse impacts due to lower crop yield and reduced access, but may also be considered beneficial by preventing erosion and providing food and shelter for desirable native species. Perception of harm can also depend on the land use or vary over time. For example, a plant producing large amounts of biomass in a pasture may be considered desirable whereas the same plant may be considered harmful (weedy) in a nature conservation area if it displaces native species. A crop plant may be desirable when deliberately planted, but undesirable as a volunteer in a following crop.

2.1.1. Considerations for streamlining procedures

Such considerations include:

- Limiting operational policies issued by the regulatory authority to areas that have already proven contentious or confusing for applicants.

Although operational policies can be usefully applied to clarify interpretation of legislation or explain decisions, they require considerable resources to draft, implement and review.

- Informing government policy-makers of uncertainties that may affect the efficiency of implementing the legislation.
- Feedback to policy-makers on issues that may impact the implementation of the legislation makes it possible for revisions to be made, where necessary, to address such issues.

2.2. Legal requirements

In different jurisdictions, national biosafety legislation for the use of GMOs has been achieved by amending existing legislation or enacting new laws. Nevertheless, legislation used for regulation includes most of the following components:

- objective (e.g. protection of the environment and health of people) and the scope of regulatory coverage,
- explanatory memorandum to provide the policy context for the legislation,
- definitions of key terms,
- establishment and details of the decision-making authority and its functions,
- details of administrative structures and processes (e.g. application processing, type and time for approval process, fee structures, provisions for variations to approvals),
- provisions for handling confidential material,
- supporting regulations to elaborate interpretation of the primary legislation,
- monitoring for compliance with conditions attached to the approval,
- enforcement powers,
- appeal structures,
- socio-economic considerations (if any).

Typically, the operation of national biosafety legislation operates within a framework of other legislation, such as:

- environmental protection legislation,
- administrative laws,

- liability and redress,
- occupational workplace health and safety,
- quarantine/biosecurity laws,
- criminal codes,
- freedom of information provisions,
- privacy laws,
- public service laws,
- judicial review provisions.

In addition to national biosafety legislation, other national and international legal instruments, including treaties and conventions, may need to be considered. If a GMO is to be transported across national boundaries, it may be subject to the Cartagena Protocol on Biosafety to the Convention on Biological Diversity (Cartagena Protocol; Secretariat of the Convention on Biological Diversity, 2000). Other relevant international obligations are directed by the World Organisation for Animal Health, the International Plant Protection Convention, and the Codex Alimentarius Commission. Decisions on commercial approvals of GMOs can also be subject to scrutiny by the World Trade Organisation in relation to potential barriers to trade.

2.2.1. Considerations for streamlining procedures

Such considerations include:

- Outsource legal advice.
- Liability and redress.

The operation of a regulatory office can cover a broad range of legal matters beyond the scope of a single officer. Therefore in small regulatory offices that receive relatively few applications, outsourcing legal advice may be more cost-efficient.

The type of liability and redress can affect implementation and uptake of the technology. Strict liability attributes liability to the originator/manufacturer of the GMO or GM product, which can affect commercialisation decisions.

2.3. Administrative procedures

Administrative processes serve to put legal requirements and policies into practice. The primary objective of administration is to ensure that procedures and systems are in place to support sound decision-making. This involves fulfilling all legally-required steps correctly.

Good administration also seeks to establish reliable, efficient processes and to maintain a complete record of relevant actions and decisions. The quality of administration is central to building a trusted regulatory system that demonstrates competence, credibility and integrity.

Important components of administration associated with regulation may include:

- application forms that clearly express the type of information required,
- application lodgement and processing procedures,
- procedures for decision-making and delegation,
- monitoring procedures for approvals,
- operational policies for achieving compliance,
- procedures for accessing, recording and maintaining information,
- access to, and use of, legal advice,
- formal arrangements with advisory bodies,
- structures for processing confidential information,
- arrangements for policy inputs,
- acquisition and maintenance of resources and structures for collection of fees,
- structures and procedures to develop and maintain linkages with other relevant government bodies,
- procedures for handling queries and consultation.

However, good administration is a balancing act. A more detailed administrative system supports greater certainty, reliability and consistency. For example, legislation may require seeking advice from certain government agencies or advisory bodies, but in the absence of appropriate administrative processes, the advice may be late in coming or could come in a form that does not support decision-making. Nevertheless, an overly detailed system can frustrate decision-making, especially when it includes unnecessary or unclear requirements.

Other important considerations for establishing appropriate administrative processes include access to resources (such as people), costs and supporting structures (e.g. business management, legal services, physical resources, procurement etc.). In addition to the initial establishment of a

regulatory system, longer term changes to the resource base may need to be considered.

Administrative costs and requirements associated with regulation also affect applicants. High costs can restrict those who can participate in developing GMOs and the types of products produced. This is of particular relevance to public research efforts and small-scale companies.

2.3.1. Considerations for streamlining procedures

Such considerations include:

- Keep the number of steps/handling processes to a minimum.
- Use the tools listed in Section 3 below to assist with developing effective and efficient processes.
- Maintain good communication between all persons in the decision-making process.
- Develop collaborations and networks, both nationally and internationally, to share knowledge, experiences and resources.
- Be prepared to change and innovate to achieve continual improvement.

2.4. Evaluation of applications

Evaluation of applications for activities with GMOs, in particular the release of a GMO into the environment, typically requires risk assessment and a risk management plan to address significant risks.

Risk, the potential for harm from an activity, can be viewed as the relationship between: 1) a source of risk; 2) harm to an object of value, and; 3) a causal linkage between 1) and 2) (Figure 1).

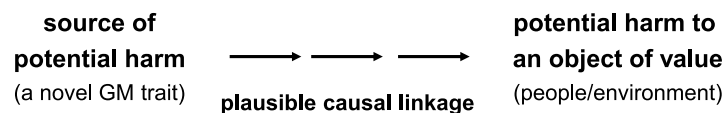


Figure 1. Structure of risk (OGTR, 2013).

Risk assessment is a structured reasoned approach to consider the potential for harm that could arise out of certain dealings with a GMO. The following questions generally guide the risk assessment process (e.g. Gray, 2012): What could go wrong? How serious could the harm be? How likely is the harm to occur? What is the level of concern? Typically therefore, risk assessment includes the following four key components (OGTR, 2013):

1. *Establishing the context* (planning/scoping) - which defines those things that should be considered in the risk assessment and how they should be considered. This includes national and international legal requirements, as well as protection goals.
2. *Risk identification* - which describes scenarios (risk hypotheses/conceptual models) whereby plausible causal pathways to harm are postulated. This will take into account the biology of the parent organism, the properties of the novel trait and the type of environment where the GMO is expected to occur.
3. *Risk characterisation* - which considers the consequences and likelihood of potential harm.
4. *Risk evaluation* - which judges the significance of risk and the overall risk. For example, a risk matrix can be used to estimate the level of risk (Figure 2).

		LEVEL OF RISK			
		Low	Moderate	High	High
LIKELIHOOD ASSESSMENT	Highly likely	Low	Moderate	High	High
	Likely	Low	Low	Moderate	High
	Unlikely	Negligible	Low	Moderate	Moderate
	Highly unlikely	Negligible	Negligible	Low	Moderate
		Marginal	Minor	Intermediate	Major
CONSEQUENCE ASSESSMENT					

Figure 2. Risk matrix to estimate the level of risk (OGTR, 2013)

Where possible, a comparative risk assessment approach is used, such that risk from a GMO is considered relative to the parent organism within the environment where the GMO is expected to be present. The focus of the assessment is whether traits modified by gene technology increase the level of risk, or give rise to additional risks.

Most approaches to risk assessment are based on the methodology described in Annex III of the Cartagena Protocol.

Often there are calls for risk assessment to acknowledge and consider uncertainty. However, it should be recognised that uncertainty is an inherent part of risk. The risk assessment is a structured, reasoned approach to address uncertainty. Therefore, the risk assessment methodology and points to consider in Annex III of the Cartagena Protocol is one such approach.

Following the outcomes of the risk assessment, risk management is then used to consider measures that mitigate or reduce the level of significant risks in such a way as to protect aspects such as the health of people and the environment. Therefore there is a focus on preventing risk from being realised rather than on reducing or repairing the resultant harm. Nevertheless, contingency plans are usually incorporated as part of any conditions imposed on the authorisation.

The risk management plan may consider a number of general questions (OGTR, 2013), such as:

- What measures are available for managing risk?
- How effective are the risk management measures?
- How feasible, practical or compatible are the risk management measures?
- Which treatment measure(s) provides the optimum and/or desired level of control?
- Do the risk management measures themselves introduce new risks or exacerbate existing ones?

The risk management plan may also consider advice received during consultation with stakeholders.

2.4.1. Considerations for streamlining procedures

Such considerations include:

- Use information from risk assessments of the same or similar GMOs approved in other jurisdictions.
- Adopt existing national and international standards (e.g. ISO 31000:2009 [ISO, 2009], ISO 15189:2012 [ISO, 2012]).

- Develop collaborations and networks, both nationally and internationally including with other regulatory agencies, to enhance knowledge and understanding of risk analysis as it is applied to GMOs and other organisms.
- Establish clear criteria for harm, including the rationale, types and degree of harm.
- Apply a proportionate response to analysing risks such that attention is focussed on risks that are significant.
- Where possible, consider the use of tried and tested systems that have been used to assess 'problematic plants', namely weeds.
- Distinguish 'need to know' information from 'nice to know'.

2.5. Communication and consultation

Release of GMOs into the environment is of interest to a wide spectrum of the community, including various government bodies, non-government organisations, community groups, businesses and individuals. Therefore, communication is an integral component of every step and process in regulatory decision-making. This includes internal communication with staff in the regulatory agency.

Communication is a continual and iterative process to provide, share or obtain information and to engage in dialogue with stakeholders. Communication provides the decision-making authority with access to the relevant factual information and analyses, as well as awareness of the needs, values and concerns of stakeholders. It is also important to communicate the reasons underpinning decisions.

Effective communication is central to effective decision-making. It relies on good governance, openness and transparency. The goals of communication relevant to regulation can be categorised as follows (OGTR, 2013):

- *Informing* – to foster understanding with different constituencies (e.g. licence/permit holders and others from the regulated community, as well as researchers, farmers, health workers, industry, consumers, interest groups and the general community). This could include providing information about regulatory processes relating to risk assessment and risk management.
- *Engagement* – to involve internal and external stakeholders in the regulation process through dialogue.

- *Building trust* – to promote trust and credibility in the ability of the decision-making authority to effectively regulate GMOs. This includes demonstrating competence, integrity and respect.

Communication processes consider the following questions (Standards Australia, 2012):

- What are the objectives of the specific communication?
- Who will be involved?
- What is to be communicated?
- How will the information be communicated?
- How will consultation be conducted?

However, communication is affected by how people understand or perceive the information that they receive, including what is regarded as risk. Perception and understanding of risk can also be influenced by personal experiences, knowledge, beliefs, values and attitudes.

Understanding how risks may be perceived can be important in ensuring effective transmission and receipt of risk communication messages. It also provides risk evaluators and decision-makers insights into psychological and social factors that may affect their perception of risk as well as that of different stakeholders, thereby influencing the communication process. This includes the type of communication channel that is considered to be appropriate and effective (e.g. forms, internet, letters, telephone, meetings, public forums, newspapers, social media etc.).

2.5.1. Considerations for streamlining procedures

Such considerations include:

- Use stakeholder mapping to identify key stakeholders.
- Use social/electronic media as a means to communicate rapidly, broadly and cost effectively.

Informing and engaging with applicants, other stakeholders and the public is crucial to building trust in regulatory decisions and ultimately acceptance of the technology. Therefore, restrictions in communication and consultation may not be cost-effective.

2.6. Decision-making

Decision-making is tailored to each jurisdiction's needs and requirements. Decision-making may be informed by considering a number of general questions listed below.

2.6.1. What types of application require authorisation?

The types of applications may include: GMOs in facilities such as: laboratories, glasshouses or animal facilities (contained use); field trials with limits and controls (confined use); commercial releases (placing on the market); import (including grain shipments intended for processing as food for people or feed for animals), and export.

In addition there may be provisions for applications to vary, surrender or transfer an authorisation to account for changes in the circumstances during the lifetime of the authorisation. Most jurisdictions also make provisions for applications to protect certain information as confidential information. Finally, there may be provisions to apply for deregulation of a GMO.

2.6.2. What provisions or procedures are there for ceasing or cancelling an authorisation?

If there are credible findings of adverse effects or breaches of conditions, there may be a need to repeal an authorisation and cease the associated activities.

2.6.3. Who is the delegated decision-maker?

There is considerable variation in the types of decision-maker, including; a Board, a Minister, an Administrator, an independent statutory office holder etc. In addition, legislation may allow the decision-maker to delegate some decisions to others.

2.6.4. Who should be consulted before reaching a decision?

Often there is a need to consult widely on applications, including advisory bodies, other government departments and agencies, and the public.

2.6.5. What matters must be taken into account in reaching a decision?

In addition to the risk assessment and risk management plan, there are typically several other considerations required before reaching a decision. Some examples of other matters that may need to be considered include socio-economic considerations and comments submitted during the

consultation. In addition, decision-making requires developing processes and procedures to ensure that valid decisions are reached, including meeting certain legislated timelines.

2.6.6. What conditions may be prescribed or imposed on an authorisation?

When an authorisation is issued there are certain conditions imposed. This is particularly the case for applications for contained or confined use of a GMO. The types of conditions may include: controls to limit the spread and persistence of the GMO; the types of activities that are permitted; documentation and record keeping requirements; the level of containment required; storage, transport and disposal requirements; data collection, including studies to be conducted; measures to manage risk; adverse effects reporting; and contingency planning.

2.6.7. Considerations for streamlining procedures

Such considerations include:

- Where available in legislation, develop criteria to implement clauses for exemption clauses (e.g. Section 20 of Ghana's Biosafety Act, 2011 [Republic of Ghana, 2011]) from certain requirements such as risk assessment.
- Where appropriate and allowable, delegate minor decisions to lower levels within the regulatory authority.
- Minimise the number of steps in the decision-making process.
- Use checklists and decision trees to ensure that all steps are completed.
- Be prepared to accept some level of uncertainty.

2.7. Monitoring for compliance

Monitoring of authorisations is most commonly applied to contained use and confined use of GMOs. For example, field trials have control measures to limit the spread and persistence of the GMO as specified in the authorisation (see Figure 3). These fields are then monitored for compliance with the conditions of the authorisation.

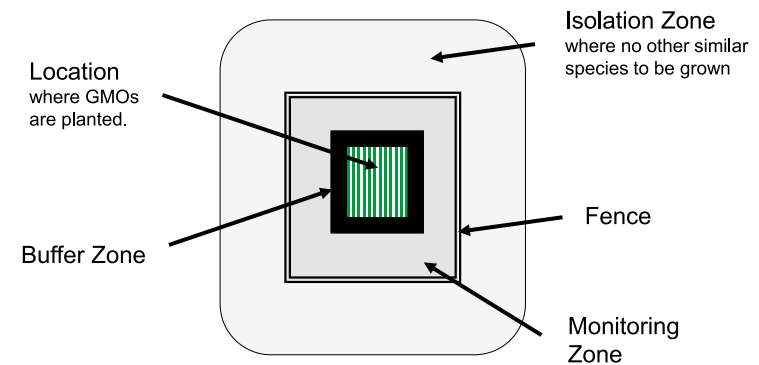


Figure 3. A field trial with controls to limit the spread and persistence of a GMO

Monitoring is conducted by inspectors that often have powers conferred by legislation. This may include powers to: search premises; examine or take samples from the premises; make audio or visual records; require answers to questions and to produce any book, document or record required by the inspector; inspect and take extracts or copies of any book, document or record, or; secure a thing prior to seizure by a warrant. Inspectors are usually required to be trained and certified. Nevertheless, greater trust in the regulatory authority may be gained through co-operative compliance, by informing, training and notifications.

2.7.1. Considerations for streamlining procedures

Such considerations include:

- Establish clear criteria for inspections, including breaches of conditions to an authorisation.
- Specify the number of monitoring visits that are considered acceptable.
- Cluster monitoring visits where possible.
- Establish procedures that foster compliance amongst the regulated community.

2.8. Compliance and Investigations

Regulation is mandatory when there are enforcement powers and penalties made available through legislation. When there is evidence of a possible breach of conditions imposed by the authorisation, then an investigation is carried out. Investigations may look at authorised activities, facilities/sites and equipment, organisation and governance, document agreements in the case of partnerships and shared services, goods and services, people and institutions, or matters such as procedures for storage, transport and disposal.

Findings of breaches from an investigation may result in directions to rectify matters, orders to cease activities, suspension or cancellation of an authorisation, or injunctions that may lead to prosecution.

2.8.1. Considerations for streamlining procedures

Such considerations include:

- Use clear guidelines for investigation that are derived from existing sources (e.g. criminal codes).
- Maintain careful records.
- Apply a proportionate response to incidents.

2.9. Check and review

The purpose of checking and reviewing all steps in the decision-making process is to ensure the right things are done, each step is done correctly, and the outcomes remain valid subject to new information. A number of feedback mechanisms may be applied both within the regulatory authority and externally through stakeholders.

Internal feedback may occur through checklists and standard operating policies, reviewing guidelines and forms, or through peer review procedures. External feedback is provided through consultation, accountability during audits, and through appeals to decisions.

2.9.1. Considerations for streamlining procedures

Such considerations include:

- Integrate checking and review as part of all processes.

Typically the decision-making process involves more than one person to view each step and procedure; this offers the opportunity to check and review each of the steps and procedures.

- Use difficult queries and applications as part of the checking and review process.

More difficult queries usually offer the opportunity to reassess the rationale and approach that is applied to certain parts of the decision-making process.

- Use external reviewers through established networks and partnerships.
- Be prepared to change and innovate to achieve continual improvement.

3. TOOLS TO SUPPORT REGULATORY DECISION-MAKING

Tools to support regulatory decision-making should be simple to understand and apply. They should assist:

- the identification of all the necessary components and steps for making sound decisions,
- the establishment of processes that are reliable, repeatable and robust,
- matching processes to available resources and skills.

Some examples of tools with broad application to regulatory decision-making include:

- standard operating procedures,
- checklists,
- guidance documents,
- decision trees,
- concept mapping,
- structured decision-making,
- networking.

3.1. Standard operating procedures

Standard operating procedures (SOPs) are widely used in administration to achieve consistent outcomes. They should be an accurate description of established practices and regularly updated to ensure continuing accuracy and relevance. SOPs should describe: 1) title/purpose of the SOP; 2) what

steps (actions) are to be followed; and, 3) who does what. Additional details that can be useful for developing an SOP include: name and position of the delegate that has authority to approve the SOP; name(s) and position(s) of people that developed the SOP; dates for review of the SOP, both previous and future dates; background information, and; the purpose(s) of certain steps.

SOPs are valuable when applied to commonly used procedures that have been well established. For example, see Box 1 for a hypothetical case study of a procedure to handle a request for declaring material as ‘Confidential Information’.

BOX 1. HYPOTHETICAL STANDARD OPERATING PROCEDURE (SOP)

Title:

Procedure to request material declared as ‘Confidential Information’ (CI)

Who does this SOP apply to?

Evaluator, Legal officer

Steps/Actions

Evaluator

1. Refer to the Department’s CI Manual for instructions on handling CI material.
2. Create a CI file.
3. Store electronic copies of CI material on password protected site.
4. Retain paper copies including email correspondence/letter on the CI file.
5. Store CI file in a C-class container.
6. Provide Legal officer with draft recommendations in relation to the CI application.

Legal officer

1. Notify applicant of the CI decision.
2. Refer to the Department’s CI Manual if asked to provide CI to other government agencies.

either a series of tick boxes that signals the completion of a specified step (see Box 2 for a hypothetical case study of lodging an application with a regulatory agency) or a specified decision (see Box 3 for a hypothetical case study of application processing).

A checklist compensates for the limits to a person’s memory and attention. Checklists have been widely adopted in hospital procedures and aviation to ensure that critical items are not forgotten. Nevertheless, the checklist can also play an important role in regulation to ensure that all legal requirements are met and that all steps in the regulatory decision-making process are considered and addressed. In addition, the checklist can inform new staff or decision-makers of all the actions necessary to arrive at legally defensible decisions.

3.3. Guidance documents

Guidance documents are widely used in regulation to communicate with the regulated community (e.g. applicants), internal staff, and other stakeholders, including the public. For example, guidance documents can provide applicants with more specific details on the decision-making process; assist decision-makers and staff within a regulatory agency to make consistent decisions; or provide stakeholders with greater understanding of legislative requirements.

BOX 2. HYPOTHETICAL CHECKLIST WITH SIMPLE TICK BOXES

Checklist for the lodgment of an application.

- Title of application recorded.
- Date of receipt recorded.
- Name and contact details of applicant provided.
- Name and contact details of project supervisor or technical contact provided.
- Approval from institutional biosafety committee (IBC) provided.
- Declaration of confidential information completed and recorded.
- Fees paid.
- Application has all required information.
- File created and file number recorded.

3.2. Checklists

Like SOPs, checklists assist with consistency and completeness when carrying out a procedure or task. The main difference from SOPs is the addition of

One particular strength with the use of guidance material is its application to addressing areas of uncertainty (e.g. defining environmental harm). As it has guidance status and is not legally binding, it is open to greater flexibility when new information becomes available or new policies are implemented.

BOX 3. HYPOTHETICAL CHECKLIST WITH DECISIONS

Checklist for consultation on an application.

According to section XXX of the Biosafety Act a consultation version of the risk assessment has been prepared.

Noted/Not noted

According to section XXY of the Biosafety Act you agree to release the risk assessment for consultation.

Agree/Disagree

According to section XXZ of the Biosafety Act you are satisfied that the applicant is suitable to hold a permit.

Satisfied/Not satisfied

According to section XYX of the Biosafety Act you approve consultation with agencies listed in Regulation ABC.

Approve/Not approve

According to section XYY of the Biosafety Act you agree to a consultation period of 30 days.

Agree/Disagree

According to section XYZ of the Biosafety Act you will inform the Minister of the Environment about consultation on the application.

Informed/Not informed

According to section XZX of the Biosafety Act clearance is requested for public notification.

Cleared/Not cleared

Examples of guidance documents include:

- forms (e.g. licence/permit application form),
- operational policy papers (e.g. acceptable cover crops following a confined field trial),
- interpretation of legal requirements (e.g. explaining what is a GMO),

- discussion papers on commonly considered issues or topics (e.g. horizontal gene transfer [Keese, 2008]),
- information/instruction documents (e.g. management of GM oilseed rape found along roadsides).

One of the most important types of guidance material is the application form, such as a request for a commercial release of a GMO. The application form is the primary means for eliciting the necessary information to process and adequately consider an application. There are four factors that should be considered when formulating each question or requested information:

1. Is the requested information expressed simply, clearly and unambiguously to assist a common understanding of the information that is required?
2. Why is the information required? A rationale should be available to justify and explain the purpose of the information that is sought.
3. What information is required? Indicators or information elements that are required should be available.
4. What is an adequate response? Can examples be provided to indicate what constitutes a response that has all the necessary and relevant information? What is regarded as sufficient information?
5. An example of how these four factors are addressed is provided in Box 4. It describes a hypothetical request that might occur in a licence/permit application form for the environmental release of a GM plant.

3.4. Decision trees

Decision trees are tree-like structures, whose branching is determined by steps in the process that require a decision (e.g. yes/no, true/false). One example is provided in Figure 4, where the decision tree is represented by a flow chart. Decision trees are simple to understand and interpret after a brief explanation. However, decision trees are less effective if decision points have significant uncertainty.

BOX 4. HYPOTHETICAL PART OF AN APPLICATION FORM

Data requirement/Question in the application form

Provide a brief summary of the purpose and intended use of the GM plant(s) proposed for environmental release.

Rationale

This summary will be used to inform the public about the proposed release of a GMO.

Type of information required (information elements)

The summary should be comprehensive and written in plain, non-technical language. It should include:

- the name of the GM plant(s) proposed for release, including an OECD identifier, where possible,
- the aim of the release,
- the area where the GM plant(s) is proposed for release,
- how the GM plant or its products would be used,
- what the genetic modification is, i.e. the introduced trait(s),
- where the genetic material has originated,
- any previous releases with the GM plant and whether it caused harm,
- any assessments or approvals, including pending approvals, by other regulators.

Example of a complete response with all necessary and appropriate information

This application is for a licence for the commercial release of GM New Dawn Cotton® (OECD identifier XYZ13890). We are proposing the commercial release of New Dawn Cotton® in all cotton growing areas, and that plant material from New Dawn Cotton® be used in the same manner as plant material from non-GM cotton and enter general commerce.

New Dawn Cotton® has been genetically modified for resistance to certain insect pests. The GM cotton contains two genes derived from a common soil bacterium. These genes confer resistance to major caterpillar pests of cotton. In addition to the genes for insect resistance, the GM cotton contains a gene from a common soil bacterium conferring tolerance to the herbicide glyphosate.

New Dawn Cotton® has been previously approved for field trials under licences ABC, ABD and ABE. There have been no reports of adverse effects on human health and safety or the environment resulting from these releases.

The oil and linters derived from this GM cotton have been approved by the Food Authority for use in human food.

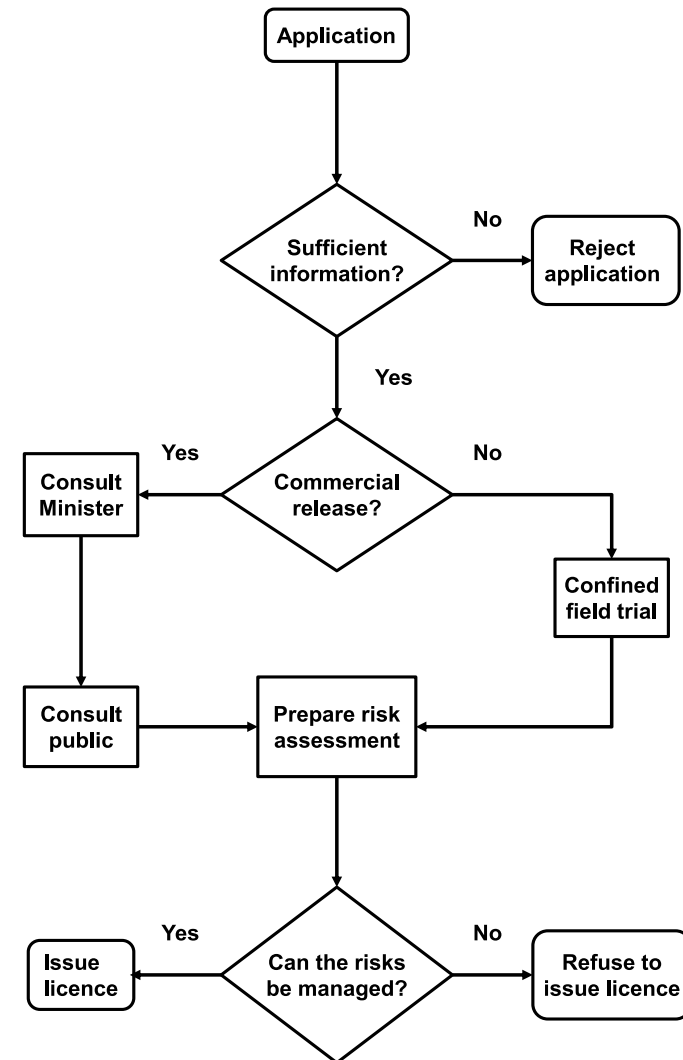


Figure 4. Hypothetical decision tree* for an application to release a GMO into the environment. *A decision is represented by a diamond (rhombus); a generic processing step is represented by a rectangle; flow from one step to another is represented by an arrow; and, start and end steps represented by a rounded rectangle.

3.5. Concept mapping

Concept maps are graphical tools to organise and represent knowledge or ideas. They include concepts enclosed by boxes and relationships between concepts represented by connecting lines and words or phrases that specify the relationship. Another characteristic of concept maps is their hierarchical nature from more general concepts to more specific concepts at the periphery. In addition, concept maps can include cross-links that show relationships between different segments or domains. Figure 5 shows one example of a concept map that can be used to identify risk scenarios associated with a GM plant.

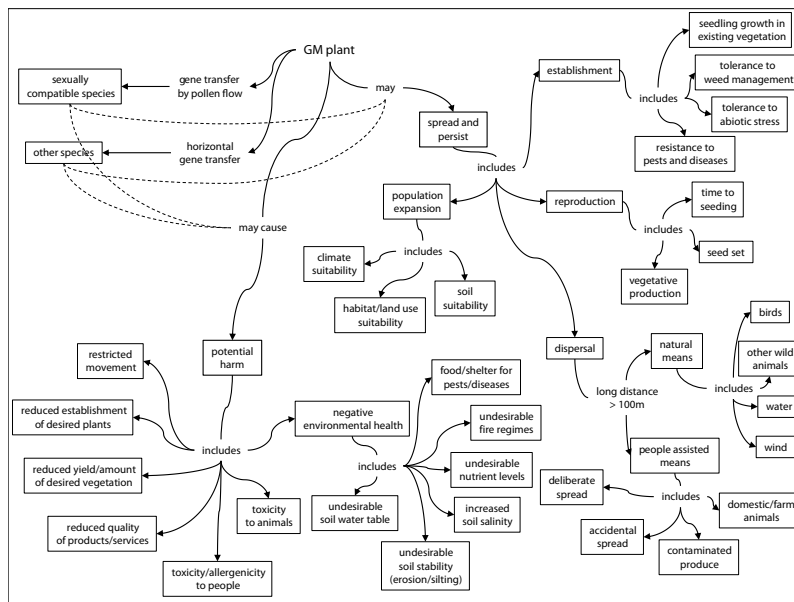


Figure 5. Hypothetical concept map for risk identification of a commercial release of a GM crop.

Concept maps emerged from the learning psychology (Ausubel et al., 1978) in which learning takes place by the assimilation of new concepts or ideas into existing frameworks. Concepts maps help to overcome the

limited capacity of working memory to process the relationships between two or three concepts, especially when faced with less familiar material, such as when identifying potential risks from a GMO. However, concept maps can also be usefully applied to other regulatory activities associated with risk communication, risk management, monitoring, compliance or even overall regulatory governance.

3.6. Structured decision-making

Decision analysis has developed many tools to help people make better decisions. One widely used tool is structured decision-making (Keeney, 2004), which adjusts the degree and type of analysis to the importance and difficulty of the problem. Structured decision-making is an organised and transparent framework for identifying and evaluating creative options and making defensible choices in difficult situations.

The key elements include:

1. *Clarify the problem* - define your decision problem so that you will solve the right problem.
2. *Define objectives and evaluation criteria* - specify what you are really trying to achieve with your decision. Objectives are statements of the fundamental ends that matter in the decision. For each objective, describe measurable indicators that serve as evaluation criteria.
3. *Develop alternatives* - complete, internally coherent and distinct solutions to choose from.
4. *Estimate consequences* - describe how well each alternative meets your objectives as measured according to your evaluation criteria.
5. *Make trade-offs and choices* - 5. balance pros and cons of different alternatives for meeting your objectives, taking into account your willingness to accept risks.
6. *Implement your decision and monitor outcomes.*

Structured decision-making can be applied to situations where a range of viable options can be chosen to address the issue. For example, the authority to regulate GMOs can be provided by: an independent Board; an advisory Board to the Minister; an independent individual; an officer within a government department; a Ministerial appointment; or a group appointed from several Ministries. Each of these alternatives has different advantages and disadvantages, which can be systematically explored through structured decision-making.

Similarly, structured decision-making could be used to explore different options to manage a confined field trial which may have several competing objectives, such as maximising security from human interference and minimising costs, or maximising continued agricultural production in the vicinity of the release site and maximising ease of identifying volunteer GMOs during monitoring.

3.7. Networking

No one person or organisation can know and understand all aspects necessary to develop and maintain an effective, efficient regulatory system. There are always limitations of time, resources and capacity. In addition, there are numerous interactions required between people and organisations. Therefore, networks, collaborations and partnerships are crucial to successful navigation of this increasingly interconnected world.

Two fundamental tenets of networking are: 1) learning from others, and; 2) cooperation, namely, sharing information and working together towards common goals. Networks are at the core of relationships within an organisation and with stakeholders.

Nevertheless, opportunities for broader networks can prove valuable. For example, this can include membership of international societies such as the International Society for Biosafety Research, the Society for Risk Analysis or the Australasian Environmental Law Enforcement and Regulators Network. Alternatively, interactions can be at a national level (e.g. a network of scientists from different regulatory agencies responsible for the regulation of biologicals and chemicals that has been established in Australia), or the association with groups interested in risk assessment and control of biological organisms that may cause harm (e.g. the Australian Weeds Risk Management Forum).

In addition, there may be opportunities to use regional groupings (e.g. the West and Central Council for Agricultural Research and Development [CORAF/WECARD] or the Association for Strengthening Agricultural Research in East and Central Africa [ASARECA]) as the basis for sharing information and resources associated with specific regulatory activities such as risk assessment and monitoring.

4. CONCLUSIONS

As shown in Section 1.1. above, nine key components have been identified for a complete functioning biosafety regulatory system. Although these components are desirable for constructing a complete and effective regulatory system, they can be adapted and streamlined to the needs of low income countries with limited resources and expertise to arrive at sound, consistent, reliable and defensible decisions. In addition, a number of simple regulatory tools have been identified which can be adapted by low income countries to facilitate the implementation of these key components and enhance the performance of their emerging biosafety regulatory systems. These include standard operating procedures, checklists, guidance documents, decision trees, concept mapping, structured decision-making, and networking. Integrating and streamlining the key components and applying the various regulatory tools can provide the basis for establishing an efficient, effective regulatory system whose outcomes include: timely, consistent, reliable and defensible decisions; a high level of trust and compliance from stakeholders and the public; openness and transparency, and; are subject to continual improvement.

5. REFERENCES

Ausubel D, Novak J & Hanesian H (1978). *Educational psychology: A cognitive view*. 2nd edition, Holt, Rinehart & Winston, New York, USA. pp. 685.

Gray A (2012). Problem formulation in environmental risk assessment for genetically modified crops: A practitioner's approach. *Collection of Biosafety Reviews* 6:10–65.

ISO (2009). *ISO 31000:2009. Risk Management - Principles and Guidelines*. International Organization for Standardization (ISO), Geneva, Switzerland. www.iso.org/iso/catalogue_detail?csnumber=43170

ISO (2012). *ISO 15189:2012. Medical Laboratories – Requirements for Quality and Competence*. International Organization for Standardization (ISO), Geneva, Switzerland. www.iso.org/iso/catalogue_detail?csnumber=56115

Keeney R (2004). Making better decision makers. *Decision Analysis* 1(4): 193-204.

Keese P (2008). Risks from GMOs due to horizontal gene transfer. *Environmental Biosafety Research* 7(3): 123-149.

OGTR (2013). *Risk Analysis Framework 2013*. Office of the Gene Technology Regulator (OGTR), Canberra, Commonwealth of Australia. www.ogtr.gov.au/internet/ogtr/publishing.nsf/content/raffinal5-toc

Republic of Ghana, 2011. *Biosafety Act, 2011- Act 831*. Parliament of the Republic of Ghana, Accra, Ghana. <http://bch.cbd.int/database/record.shtml?documentid=103126>

Secretariat of the Convention on Biological Diversity (2000). *Cartagena Protocol on Biosafety to the Convention on Biological Diversity*. Secretariat of the Convention on Biological Diversity, Montreal, Canada. <http://bch.cbd.int/protocol/text/>

Standards Australia (2012). HB 89-2012. *Risk Management - Guidelines on Risk Assessment Techniques*. Standards Australia, Sydney, Australia. <http://infostore.saiglobal.com/EMEA/Details.aspx?ProductID=1523735>