



Convention on Biological Diversity

Distr.
GENERAL

UNEP/CBD/BS/COP-MOP/7/INF/6¹
10 June 2014

ENGLISH ONLY

CONFERENCE OF THE PARTIES TO THE CONVENTION
ON BIOLOGICAL DIVERSITY SERVING AS THE
MEETING OF THE PARTIES TO THE CARTAGENA
PROTOCOL ON BIOSAFETY

Seventh meeting

Pyeongchang, Republic of Korea, 29 September-3 October 2014

Item 12 of the provisional agenda*

REVISED TRAINING MANUAL ON RISK ASSESSMENT OF LIVING MODIFIED ORGANISMS

Note by the Executive Secretary

1. In its decision BS-VI/12, the Conference of the Parties serving as the meeting of the Parties to the Protocol (COP-MOP) mandated the Online Forum on Risk Assessment and Risk Management and the Ad Hoc Technical Expert Group (AHTEG) on Risk Assessment and Risk Management to “[c]oordinate, in collaboration with the Secretariat, the development of a package that aligns the Guidance on Risk Assessment of Living Modified Organisms (e.g. the Roadmap) with the training manual ‘Risk Assessment of Living Modified Organisms’ in a coherent and complementary manner, for further consideration of the Parties, with the clear understanding that the Guidance is still being tested”.
2. The Online Forum and the AHTEG held several rounds of discussion with a view to improving the coherence between the Roadmap and the “Manual on Risk Assessment of Living Modified Organisms” (i.e. the Manual).²
3. Taking into account the fact that the testing of the Guidance, which comprises the Roadmap, was still in progress and the fact that the COP-MOP may wish to establish a process for its improvement, the alignment between the contents of the Roadmap and the Manual was limited to revising and restructuring the Manual alone while keeping the Roadmap untouched throughout the process.
4. The resulting revised Manual is being made available as an information document for the COP-MOP at its seventh meeting.

¹ This document was previously published as UNEP/CBD/BS/AHTEG-RA&RM/5/INF/1 on 15 May 2014.

* UNEP/CBD/BS/COP-MOP/7/1.

² Available at http://bch.cbd.int/onlineconferences/forum_ra/discussion.shtml.

2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32

Training Manual on Risk Assessment of Living Modified Organisms in the context of the Cartagena Protocol on Biosafety



Convention on
Biological Diversity



33

34

35

36

37

38

39

40

41

42

43

44

45

46

47

48

49

50

51

52

53

54

55

56

57

58

59

60

61

(This page was intentionally left blank)

62 Module 1:

63 Overview of Biosafety and the Cartagena
64 Protocol on Biosafety

65

66

67

68

69

70

71

72

73

74

75

76

77

78

79

80

81

82

83

84

85

86

87

88

89

90

91

92

93

(This page was intentionally left blank)

94 **Contents of this module**

95	Introduction to biosafety and the Cartagena Protocol on Biosafety
96	History of the Protocol
97	What is biosafety?
98	What are living modified organisms?
99	Objective and scope of the Protocol
100	Living modified organisms for intentional introduction into the environment - Advanced Informed
101	Agreement (AIA)
102	Living modified organisms for direct use as food, feed, or for processing (LMOs-FFP)
103	Competent National Authorities
104	Risk Assessment (Article 15 and Annex III)
105	Biosafety-clearing House
106	Other provisions under the Protocol
107	Other international biosafety-related bodies
108	International Plant Protection Convention
109	Codex Alimentarius Commission
110	Food and Agriculture Organization
111	World Organisation for Animal Health
112	Organisation for Economic Cooperation and Development
113	World Trade Organization
114	Bilateral, regional and multilateral agreements
115	References
116	Annex - Techniques used in modern biotechnology
117	Commonly used methods for genetic modification of plants
118	Examples of commercialized LMOs
119	
120	
121	

122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169

(This page was intentionally left blank)

170 **Using this module**

171 This module contains introductory sections explaining basic concepts in biosafety and an introduction to
 172 the Cartagena Protocol on Biosafety and other international biosafety-related bodies and organizations.
 173 The section on the Cartagena Protocol on Biosafety explains its history, scope and objective, and provides
 174 an overview of its relevant articles and provisions.

175 This module also includes a section on other international bodies involved in risk assessment in the
 176 context of biosafety, such as the Food and Agriculture Organization of the United Nations (FAO), the
 177 Codex Alimentarius, the International Plant Protection Convention (IPPC), the World Organisation for
 178 Animal Health (OIE), the World Trade Organization (WTO), the Organisation for Economic Cooperation
 179 and Development (OECD), as well as bilateral and multilateral agreements.

180 **Introduction to biosafety and the Cartagena Protocol on Biosafety**

181 *History of the Protocol*

182 The United Nations Conference on Environment and Development (also known as the “Earth Summit”),
 183 held in Rio de Janeiro in 1992 marks a significant achievement in the overall policy of the United Nations
 184 on the environment. Several documents resulting from that meeting constitute the basis of the
 185 international law on biosafety, such as Agenda 21, the Rio Declaration on Environment and Development
 186 and the United Nations Convention on Biological Diversity.

187 Agenda 21 is a comprehensive programme for action in social and economic areas and for conserving and
 188 managing the natural resources. Its chapter 16 addresses the “Environmentally sound management of
 189 biotechnology” (see box below) by recognising that modern biotechnology can make a significant
 190 contribution to enhancing food security, health and environmental protection, and outlining the need for
 191 international agreement on principles to be applied to risk assessment and management and set out the
 192 implementation of safety mechanisms on regional, national, and international levels.

193 ***Agenda 21, chapter 16, paragraph 29***

194 “There is a need for further development of internationally agreed principles on risk assessment and
 195 management of all aspects of biotechnology, which should build upon those developed at the national
 196 level. Only when adequate and transparent safety and border-control procedures are in place will the
 197 community at large be able to derive maximum benefit from, and be in a much better position to accept
 198 the potential benefits and risks of, biotechnology.”

199 *Source: UNCED (1992a).*

200 The Rio Declaration on Environment and Development is a series of principles defining the rights and
 201 responsibilities of States. Principle 15 allows countries to take precautionary action to prevent
 202 environmental degradation where there are threats, but no conclusive evidence, of serious or irreversible
 203 damage (see box below).

204

205 *Principle 15 of the Rio Declaration on Environment and Development*

206 “In order to protect the environment, the precautionary approach shall be widely applied by States
207 according to their capabilities. Where there are threats of serious or irreversible damage, lack of full
208 scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent
209 environmental degradation.”

210 *Source: UNCED (1992b).*

211 The Convention on Biological Diversity (CBD) was inspired by the global community's growing
212 commitment to sustainable development. It represents a dramatic step forward in the conservation of
213 biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits
214 arising from the use of genetic resources. The CBD addresses access to biotechnology and the sharing of
215 its benefits in articles 16 (“Access to and Transfer of Technology”) and 19 (“Handling of Biotechnology
216 and Distribution of its Benefits”). The issue of safety in biotechnology is addressed in articles 8(g) and
217 19(3) of the CBD.

218 More specifically, in Article 8(g), Parties to the CBD are called upon to establish or maintain means to
219 regulate, manage or control the risks associated with the use and release of living modified organisms
220 (LMOs) resulting from biotechnology which are likely to have adverse impacts on the conservation and
221 sustainable use of biological diversity. In Article 19(3) the Parties are called upon to consider the need for
222 and modalities of a protocol for the safe transfer, handling and use of LMOs resulting from biotechnology
223 that may have adverse effect on the conservation and sustainable use of biological diversity.

224 *Article 8(g). In-situ Conservation of the Convention on Biological Diversity*

225 “Each Contracting Party shall, as far as possible and as appropriate:

226 Establish or maintain means to regulate, manage or control the risks associated with the use and release of
227 living modified organisms resulting from biotechnology which are likely to have adverse environmental
228 impacts that could affect the conservation and sustainable use of biological diversity, taking also into
229 account the risks to human health”.

230 *Source: Convention on Biological Diversity (1992).*

231

232 *Article 19(3). Handling of Biotechnology and Distribution of its Benefits of the Convention on*
233 *Biological Diversity*

234 “The Parties shall consider the need for and modalities of a protocol setting out appropriate procedures,
235 including, in particular, advance informed agreement, in the field of the safe transfer, handling and use of
236 any living modified organism resulting from biotechnology that may have adverse effect on the
237 conservation and sustainable use of biological diversity.”

238 *Source: Convention on Biological Diversity (1992).*

239 Taking into account the provisions above, the Conference of the Parties to the Convention on Biological
240 Diversity decided, at its second meeting, to develop a protocol on biosafety, specifically focusing on the
241 transboundary movement of LMOs that may have adverse effects on the conservation and sustainable use
242 of biological diversity taking into account human health.

243 As a preliminary tool to serve as interim guidance for biosafety, a set of International Technical
244 Guidelines for Safety in Biotechnology was drafted by UNEP and adopted by the Global Consultation of
245 Government-designated Experts in Cairo, Egypt in December 1995.

246 In 1996, the Conference of the Parties for the Convention on Biological Diversity established an Open-
247 ended *Ad Hoc* Working Group on Biosafety to develop a draft protocol. This Working Group met six
248 times between 1996 and 1999 and, at the conclusion of its last meeting, a draft protocol was submitted for
249 consideration by the Conference of the Parties at an extraordinary meeting in February 1999, in
250 Cartagena, Colombia. The Conference of the Parties was not able to finalize its work in Cartagena. As a
251 result, the Conference of the Parties suspended its first extraordinary meeting and agreed to reconvene as
252 soon as possible.

253 The Conference of the Parties reconvened and adopted the Cartagena Protocol on Biosafety on 29 January
254 2000 in Montreal, Canada. The Protocol entered into force on 11 September 2003 upon ratification by the
255 fiftieth Party. As of September 2011, 161 Parties had acceded/ratified the Protocol.

256 ***What is Biosafety?***

257 In its broad sense, the term biosafety refers to the protection of human health and the environment from
258 potential harm due to biological agents.

259 Under the Convention on Biological Diversity (CBD), and more specifically under the Cartagena Protocol
260 on Biosafety (hereinafter “the Protocol”)³, the term biosafety essentially refers to safety procedures aimed
261 at regulating, managing or controlling the risks associated with the use and release of LMOs resulting
262 from biotechnology which are likely to have adverse environmental impacts that could affect the
263 conservation and sustainable use of biological diversity, taking also into account risks to human health.
264 Biosafety comprises multidisciplinary scientific fields including, but not limited to biology, ecology,
265 microbiology, molecular biology, animal and plant pathology, entomology, agriculture and medicine as
266 well as legal and socio-economic considerations, and public awareness.

267 ***What are living modified organisms?***

268 According to the Cartagena Protocol on Biosafety:⁴

- 269 a) “Living modified organism” means any living organism that possesses a novel combination of
270 genetic material obtained through the use of modern biotechnology;
- 271 b) “Modern biotechnology” means the application of:
- 272 i. *in vitro* nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA) and
273 direct injection of nucleic acid into cells or organelles; or
- 274 ii. fusion of cells beyond the taxonomic family;
- 275 that overcome natural physiological reproductive or recombination barriers and that are not
276 techniques used in traditional breeding and selection.

³ The text of the Cartagena Protocol on Biosafety is available at <http://bch.cbd.int/protocol/text/> .

⁴ Article 3, paragraphs (g) and (i).

277 An LMO is therefore an organism that contains a novel combination of genetic material and results from
278 (i) *in vitro* modification of nucleic acid (DNA or RNA) molecules; or (ii) cell fusion between organisms
279 of different taxonomic families. In either case, for an organism to be considered an LMO, the techniques
280 used in its development should be ones “that overcome natural physiological reproductive or
281 recombination barriers and that are not techniques used in traditional breeding and selection”.

282 Modern biotechnology techniques include, but are not limited to, *in vitro* DNA and RNA techniques for
283 the modification of genetic material (e.g. by insertion, modification or deletion of genes or other nucleic
284 acid sequences) in all types of organisms, such as plants, animals, microbes and viruses.

285 ***Objective and scope of the Protocol***

286 The objective of the Protocol is “to contribute to ensuring an adequate level of protection in the field of
287 the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that
288 may have adverse effects on the conservation and sustainable use of biological diversity, taking also into
289 account risks to human health, and specifically focusing on transboundary movements”.

290 The Protocol establishes rules and procedures for the safe handling, transfer, and use of LMOs. The
291 Protocol focuses on the transboundary movement of LMOs destined for introduction into the environment
292 and those intended for use directly as food, feed or for processing. The protocol seeks to protect
293 biological diversity, taking into account human health, from the potential risks posed by living modified
294 organisms resulting from modern biotechnology (UNEP, 2006).

295 All LMOs that may have adverse effects to biodiversity or human health are within the scope of the
296 Protocol. Nevertheless, some types of LMOs may be excluded from some provisions, as indicated below:

297 ***Scope of the Cartagena Protocol on Biosafety***

298 ► ***LMOs subject to the provisions of the Protocol***

299 All LMOs [that] may have adverse effects on the conservation and sustainable use of biological
300 diversity, taking also into account risks to human health (Article 4).

301 ► ***LMOs excluded from the Protocol’s provisions on transboundary movements***

302 LMOs that are pharmaceuticals for humans that are addressed by other international organizations or
303 agreements (Article 5).

304 *Source: IUCN (2003).*

305 ***Living modified organisms for intentional introduction into the environment -*** 306 ***Advanced Informed Agreement (AIA)***

307 The Advanced Informed Agreement (AIA) defines mandatory procedures to be applied to the first
308 transboundary movement of an LMO for intentional introduction into the environment. LMOs intended
309 for direct use as food, feed, or for processing are subject to a different procedure, as outlined in the next
310 section.

311 The AIA procedure begins with the Party of export or the exporter notifying the Party of import of the
 312 proposed transboundary movement of an LMO for intentional introduction into the environment. The
 313 notification must contain at a minimum the information specified in Annex I of the Protocol including,
 314 among other things, contact details of the exporter and importer, name and identity of the LMO and its
 315 intended use, as well as a risk assessment report consistent with Annex III of the Protocol.

316 The Party of import has 90 days to acknowledge the receipt of the notification, and 270 days to
 317 communicate its decision to the notifier and the Biosafety Clearing-House (BCH).⁵ In its decision, the
 318 Party of import may approve⁶ or prohibit the import of the LMO, request further information or extend
 319 the decision period for a defined amount of time. If the Party of import does not communicate its decision
 320 within 270 days, it should not be understood that consent was given.

321 ***Application of the Advanced Informed Agreement (AIA) procedure***

322 ► ***LMOs subject to AIA provisions***

323 LMOs intended for intentional introduction into the environment (Article 7(1)).

324 ► ***LMOs excluded from the Protocol's AIA provisions***

- 325 • LMOs in transit (Article 6(1)).
- 326 • LMOs destined for contained use in the Party of import (Article 6(2)).
- 327 • LMOs intended for direct use as food or feed, or for processing (LMO-FFPs) (Article 7(2)).
- 328 • LMOs identified by the meeting of the Parties to the Protocol as being not likely to have
 329 adverse impacts (Article 7(4)).

330 *Source: IUCN (2003).*

331 ***Living modified organisms for direct use as food, feed, or for processing*** 332 ***(LMO-FFPs)***

333 According to Article 11 of the Protocol, a Party that makes a final decision regarding domestic use,
 334 including placing on the market, of an LMO that may be subject to transboundary movement for direct
 335 use as food or feed, or for processing shall submit to the BCH the information specified in Annex II of the
 336 Protocol, within fifteen days. This information includes, among other things, the name and identity of the
 337 LMO and its approved uses, as well as a risk assessment report consistent with Annex III of the Protocol
 338 (see Article 11(1)).

339 ***Competent National Authorities***

340 Each Party should designate one or more competent national authorities (CNAs) who will perform the
 341 administrative functions required by the Protocol and are authorized to take decisions on the LMOs for
 342 which they are designated (see Module 2).

⁵ Unless article 10, paragraph 2(b) applies.

⁶ A decision that approves the use of an LMO may be done with or without conditions. If there are conditions, the decision must set out the reasons for the conditions.

343 ***Risk Assessment (Article 15 and Annex III)***

344 **Article 15** of the Protocol sets out the provisions for Parties to conduct risk assessments of LMOs. It
345 requires that risk assessments be carried out in a scientifically sound manner in accordance to Annex III
346 and taking into account recognized risk assessment techniques.

347 While the Party considering permitting the import of an LMO is responsible for ensuring that a risk
348 assessment is carried out, it has the right to require the exporter to do the work or to bear its cost. This is
349 particularly important for many developing countries (SCBD, 2003).

350 The Protocol, therefore, empowers governments to decide whether or not to accept imports of LMOs on
351 the basis of risk assessments. These assessments aim to identify and evaluate the potential adverse effects
352 that an LMO may have on the conservation and sustainable use of biodiversity in the receiving
353 environments.

354 **Annex III** sets out the general principles and methodology for the risk assessment process.

355 The general principles for conducting a risk assessment under the Protocol are that (i) it must be carried
356 out in a scientifically sound and transparent manner and on a case-by-case basis, (ii) lack of scientific
357 knowledge or scientific consensus should not necessarily be interpreted as indicating a particular level of
358 risk, an absence of risk, or an acceptable risk, and (iii) risks of LMOs should be considered in the context
359 of the risks posed by the non-modified recipients or parental organisms in the likely potential receiving
360 environment.

361 Individual Parties use these general principles to guide the development and implementation of their own
362 national risk assessment process (see Module 2).

363 The following are considerations regarding some of the general principles for risk assessment:

364 **Scientific soundness** – The Cartagena Protocol explicitly states that risk assessments should be
365 carried out in a scientifically sound manner. The principle of scientific soundness entails that risk
366 assessments are to be undertaken in a systematic way on the basis of verifiable and reproducible
367 information by, for example, reporting on methods and data in sufficient detail to enable others to repeat
368 the steps of the risk assessment independently. Some countries have integrated this principle into their
369 own procedures with specific suggestions about what type of information is appropriate for use in a risk
370 assessment. In many cases, different sources and criteria for scientifically sound information have been
371 set, ranging from scientific literature, studies presented by the notifier and expert opinions, etc.
372 Consultations among scientific experts may also be considered as an appropriate means for gathering such
373 information.

374 **Transparency** – Annex III states that risk assessments should be conducted in a transparent
375 manner. Most countries with National Biosafety Frameworks (NBFs) have procedures in place to ensure
376 the transparency of risk assessments. The CNAs often show what transparency mechanism is in place to
377 handle notifications and how the mechanism is applied in each case. The level of transparency, however,
378 may range from public notification to broad public involvement.

379 Some countries, for instance, make the necessary requirements for conducting risk assessments available
380 online and, if an approval is granted for release of an LMO into the environment, a public notification is

381 usually issued by posting the release online (see also provisions of Article 23 on “Public Participation”
382 and the section below on “Stakeholder participation”).

383 ***Example 1 – Need for transparency***

384 “Transparency is needed in all parts of risk assessments, including:

- 385 1) the objective and scope
386 2) the source, nature and quality of the data, detailed methods, explicit assumptions, variabilities,
387 identified uncertainties and their significance for the outcome
388 3) the output and conclusions

389 A transparent risk assessment should be clear, understandable and reproducible. It may help the clarity of
390 the text if particularly complex technical descriptions are annexed to the assessment. [...]

391 Transparency in risk assessment contributes to:

- 392 • meeting the legitimate needs of stakeholders to understand the basis for risk assessment;
393 • allowing an informed debate on scientific issues;
394 • providing a framework in which consumers can have confidence;”

395
396 *Source: EFSA (2009).*

397

398 ***Case-by-case*** – Annex III states that risk assessments should be carried out on a case-by-case
399 basis, i.e. a commonly accepted approach where each LMO is considered relative to the environment in
400 which the release is to occur and to the intended use of the LMO. The required information may vary in
401 nature and level of detail from case-to-case, depending on the LMO concerned, its intended use and the
402 likely potential receiving environment.

403 The legal frameworks of some countries may also specify other elements to be taken into consideration in
404 each “case”.

405 ***Example 2 – The case-by-case basis is fundamental to risk assessment of LMOs***

406 A case-by-case approach is one where each release of an LMO is considered relative to the environment
407 in which the release is to occur, and/or to the intended use of the LMO in question. A risk assessment
408 performed for a particular LMO intended to be introduced to one environment may not be sufficient when
409 assessing the possible adverse effects that may arise if that LMO is to be released under different
410 environmental conditions, or into different receiving environments. A risk assessment performed for a
411 particular use of a particular LMO may not be sufficient when assessing the possible adverse effects that
412 may arise if that LMO is to be used in different ways. Because of this, it is important for each case to be
413 addressed separately, taking into account specific information on the LMO concerned, its intended use,
414 and its potential receiving environment.

415 *Source: IUCN (2003).*

416 Considerations on how to apply these two general principles when conducting a risk assessment are
417 discussed in Module 3.

418 Annex III also contains a number of steps for conducting the risk assessment as well as points to consider
419 on the technical and scientific details regarding, for example, the characteristics of the genetic
420 modification, biological characteristics of the LMO, differences between the LMO and its recipient
421 organism, its intended use, the likely receiving environment, amongst other things.

422 Module 3 of this training manual explains each step of the risk assessment process according to Annex III
423 of the Protocol.

424 ***The Biosafety Clearing-House***

425 The Biosafety Clearing-House (BCH; <http://bch.cbd.int>) is a mechanism set up under the Cartagena
426 Protocol on Biosafety to facilitate the exchange of information on LMOs and assist countries that are
427 Parties to the Protocol to better comply with their obligations.

428 The BCH provides open and easy access to a variety of scientific, technical, environmental, legal and
429 capacity building information provided in all 6 languages of the UN.

430 The BCH contains the information that must be provided by Parties to the Protocol, such as decisions on
431 release or import of LMOs, risk assessments, competent national authorities, and national laws.

432 Governments that are not Parties to the Protocol are also encouraged to contribute information to the
433 BCH, and in fact a large number of the decisions regarding LMOs have been registered in the BCH by
434 non-Party governments.

435 The records of decisions, risk assessments, LMOs, donor and recipient organisms, and DNA sequences
436 are cross-referenced in a way that facilitates data retrieval. For instance, while looking at an LMO record,
437 all the records for the risk assessment that reference that specific LMO can be easily accessed and
438 retrieved.

439 The BCH also contains other relevant information and resources, including information on national
440 contacts, capacity-building, a roster of government-nominated biosafety experts, and links to other
441 websites, publications and databases through the Biosafety Information Resource Centre (BIRC).

442 ***Other provisions under the Protocol***

443 In addition to the provisions above, the Protocol also requires the Parties to the Protocol, consistent with
444 their international obligations, to consult the public during the decision-making process regarding LMOs
445 (Article 23); make the results of such decisions available to the public (Article 23) and allow the decision-
446 making process to take into account socio-economic considerations arising from the impact of the LMOs
447 on the conservation and sustainable use of biodiversity (Article 26).

448 **Other International Biosafety-related Bodies**

449 Several other international bodies and organizations carry out activities that are relevant to the trade and
450 environmental aspects of LMOs. A brief overview of these bodies is provided below.

451 ***International Plant Protection Convention***

452 The International Plant Protection Convention (IPPC; www.ippc.int) is a multilateral treaty for
453 international cooperation in plant protection. It aims to protect plant health while facilitating
454 international trade. The IPPC applies to cultivated plants, natural flora and plant products and includes
455 both direct and indirect damage by pests (including weeds). The IPPC was adopted by the Conference
456 of the FAO in 1951. There are currently 173 contracting Parties to the IPPC.

457 The governing body of the IPPC is the Commission on Phytosanitary Measures (CPM). The CPM has
458 adopted a number of International Standards for Phytosanitary Measures (ISPMs) that provide guidance
459 to countries and assist contracting Parties in meeting the aims of the convention. The IPPC is
460 recognized by the World Trade Organization as the relevant international standard setting body for
461 plant health. Application of ISPMs is not mandatory; however under the WTO-SPS Agreement (see
462 below) phytosanitary measures based on international standards do not need additional scientific or
463 technical justification.

464 ISPM No. 11 (IPPC, 2004) describes the factors to consider when conducting a pest risk analysis (PRA)
465 to determine if a pest is a quarantine pest. The main text of the standard (indicated with “S2”
466 throughout the text) and particularly Annex 3 of this ISPM includes guidance on conducting PRA on
467 LMOs.

468 In order to increase member countries' capacity to conduct pest risk analysis, the IPPC has developed a
469 training course and training materials.⁷

470 ***Codex Alimentarius Commission***

471 The Codex Alimentarius Commission (CAC; www.codexalimentarius.net) is a subsidiary body of the
472 FAO and the World Health Organization (WHO) established in 1961-63 to protect the health of
473 consumers and ensure fair practices in food trade. It currently has 166 members.

474 Codex Alimentarius, which means "food code", is a compilation of standards, codes of practice,
475 guidelines and recommendations on food safety prepared by the Commission. In the area of foods derived
476 from biotechnology, the Codex provides guidance on human health risk analysis in its “Principles for the
477 Risk Analysis of Foods Derived from Modern Biotechnology” (CODEX, 2003) and in its “Working
478 Principles for Risk Analysis for Food Safety for Application by Governments” (CODEX, 2007).

⁷ The IPPC training materials are available at <https://www.ippc.int/index.php?id=186208> .

479 ***Food and Agriculture Organization***

480 The Food and Agriculture Organization (FAO; www.fao.org) of the United Nations also carries out
481 activities on biosafety and biosecurity. Among these, the FAO Working Group on Biosafety is
482 responsible for two of FAO's Priority Areas for Interdisciplinary Action (PAIAs), namely "Biosecurity
483 for Agriculture" and "Food Production and Biotechnology Applications in Agriculture, Fisheries and
484 Forestry".

485 ***World Organisation for Animal Health***

486 The World Organisation for Animal Health (OIE; www.oie.int) is an international intergovernmental
487 organization founded in 1924 for improving animal health worldwide. As of June 2010, the OIE had 176
488 member countries.

489 The objectives of the OIE are to: (a) guarantee the transparency of animal disease status world-wide; (b)
490 collect, analyze and disseminate veterinary scientific information, (c) provide expertise and promote
491 international solidarity for the control of animal diseases; and (d) guarantee the sanitary safety of world
492 trade by developing sanitary rules for international trade in animals and animal products.

493 Within the mandates of the OIE, the principal aim of import risk analysis is to provide importing
494 countries with an objective and defensible method of assessing the disease risks associated with the
495 importation of animals, animal products, animal genetic material, feedstuffs, biological products and
496 pathological material.

497 ***Organisation for Economic Cooperation and Development***

498 The Organisation for Economic Cooperation and Development (OECD; www.oecd.org) provides a
499 setting where governments compare policy experiences, seek answers to common problems, identify good
500 practice and coordinate domestic and international policies.

501 With regard to risk assessment, the OECD has published the "Recombinant DNA Safety Considerations"
502 (OECD, 1986) and consensus documents, which focus on the biology of the recipient organisms or
503 introduced traits and are useful in background preparation for an LMO risk assessment.⁸

504 ***World Trade Organization***

505 The World Trade Organization (WTO; www.wto.org) is an international organization responsible for
506 establishing the rules of trade between nations. It has a number of agreements that affect the trade of
507 LMOs. One such agreement is the international treaty of "Agreement on the Application of Sanitary and
508 Phytosanitary Measures", also known as the SPS Agreement.

509 The SPS Agreement concerns the application of sanitary and phytosanitary measures for food safety and
510 animal and plant health regulations and may apply to LMOs. Article 5 of the SPS Agreement is of interest
511 in the context of this training material since it addresses risk assessment and the determination of the

⁸ Available at
<http://www.oecd.org/science/biotrack/consensusdocumentsfortheworkonthesafetyofnovelfoodsandfeeds.htm>.

512 appropriate level of sanitary or phytosanitary protection. Article 3 of the SPS Agreement recognizes the
513 standards, guidelines and recommendations set by IPPC, OIE and Codex Alimentarius Commission.

514 Other WTO agreements, such as the Technical Barriers to Trade (TBT) Agreement, Agreement on Trade-
515 Related Aspects of Intellectual Property Rights (TRIPs) and the General Agreement on Tariffs and Trade
516 (GATT) may also apply to LMOs.

517 *Bilateral, regional and multilateral agreements*

518 In addition to international treaties and standards, countries may engage in bilateral, regional and
519 multilateral agreements, such as free-trade agreements (FTAs), provided they are consistent with the
520 objective of the Protocol and do not result in a lower level of protection than that provided for by the
521 Protocol. Such agreements could also be used to undertake shared responsibilities in assessing risks to
522 facilitate decisions on LMOs.⁹

523 **References**

524 CODEX (2003) Principles for the Risk Analysis of Foods Derived from Modern Biotechnology, CAC/GL
525 44-2003. Codex Alimentarius Commission, Joint FAO/WHO Food Standards Programme. Available at
526 http://www.codexalimentarius.net/download/standards/10007/CXG_044e.pdf (access June 2010).

527 CODEX (2007) Working Principles for Risk Analysis for Food Safety for Application by Governments,
528 CAC/GL 62-2007. Codex Alimentarius Commission, Joint FAO/WHO Food Standards Programme.
529 Available at www.codexalimentarius.net/download/standards/10751/CXG_062e.pdf (access June 2010).

530 Convention on Biological Diversity (1992) Available at <http://www.cbd.int/doc/legal/cbd-un-en.pdf>
531 (access June 2010).

532 EFSA (2009) Scientific Opinion: Transparency in Risk Assessment – Scientific Aspects. Guidance of the
533 Scientific Committee on Transparency in the Scientific Aspects of Risk Assessments carried out by
534 EFSA. Part 2: General Principles. Available at <http://www.efsa.europa.eu/en/efsajournal/doc/1051.pdf>
535 (access August 2013).

536 IPPC (2004) ISPM No. 11: Pest risk analysis for quarantine pests including analysis of environmental
537 risks and living modified organisms. Available at
538 https://www.ippc.int/file_uploaded/1146658377367_ISPM11.pdf (access June 2010).

539 IUCN (2003) An Explanatory Guide to the Cartagena Protocol on Biosafety. Available at
540 <http://bch.cbd.int/database/record-v4.shtml?documentid=41476> (access June 2010).

541 James C (2012) Global Status of Commercialized Biotech/GM Crops: 2012. ISAAA Brief No. 44.
542 ISAAA: Ithaca, NY.

⁹ According WTO (at http://www.wto.org/english/tratop_e/region_e/region_e.htm), the overall number of Regional Trade Agreements (RTAs) in force has been increasingly steadily, a trend likely to be strengthened by the many RTAs currently under negotiations. Of these RTAs, Free Trade Agreements (FTAs) and partial scope agreements account for 90%, while customs unions account for 10 %. The Regional Trade Agreements Information System (RTA-IS), at <http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx>, contains information on those agreements that have either been notified, or for which an early announcement has been made, to the WTO.

- 543 Mirkov TE (2003) The molecular basis of genetic modification and improvement of crops. In: Chrispeels
544 MJ, Sadava DE (eds.) Plants, Genes and Crop Biotechnology. Jones and Bartlett Publishers, 2nd edition.
- 545 North Carolina State University (website) Available at <http://www.ces.ncsu.edu/resources/crops/ag546-1>
546 (access July 2010).
- 547 OECD (1986) Recombinant DNA Safety Considerations. Available at
548 <http://www.oecd.org/dataoecd/43/34/40986855.pdf> (access June 2010).
- 549 SCBD-UNEP (2003) An introduction to the Cartagena Protocol on Biosafety. Secretariat of the
550 Convention on Biological Diversity (SCBD) and United Nations Environment Programme
551 (UNEP) Available at <http://www.cbd.int/doc/press/presskits/bs/cpbs-unep-cbd-en.pdf> (access June 2010).
- 552 UNCED (1992a) Agenda 21. United Nations Conference on Environment and Development (UNCED),
553 Rio de Janeiro, Brazil, 3-14 June 1992. Available at <http://www.un.org/esa/dsd/agenda21> (access June
554 2010).
- 555 UNCED (1992b) Rio Declaration on Environment and Development. United Nations Conference on
556 Environment and Development (UNCED), Rio de Janeiro, Brazil, 3-14 June 1992. Available at
557 <http://www.unep.org/Documents.Multilingual/Default.asp?documentid=78&articleid=1163> (access June
558 2010).
- 559

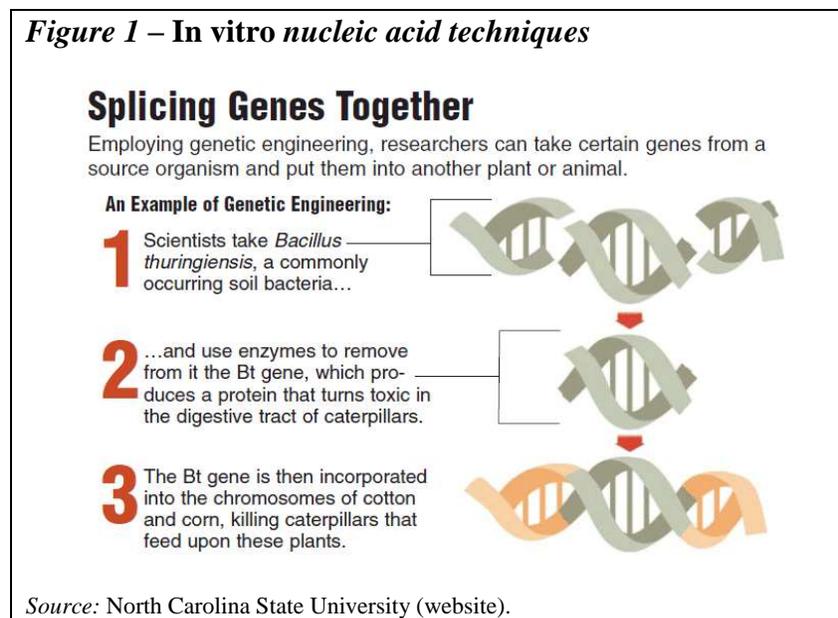
560 **Annex - Techniques used in modern biotechnology**

561 *Overview of techniques used in modern biotechnology*

562 LMOs are most commonly developed through the use of *in vitro* nucleic acid techniques by inserting,
563 deleting or modifying a gene or DNA/RNA sequence in a recipient or parental organism.

564 The terms genetic modification, genetic engineering, recombinant DNA and DNA manipulation are terms
565 that apply to the direct modification of an organism's genes. The terms genetically modified organism
566 (GMO) as well as genetically engineered or transgenic organism are often used interchangeably with
567 LMO. The Cartagena Protocol emphasizes the "living" nature of the organism, and some of its provisions
568 also apply to processed materials that originate from LMOs and contain detectable novel combinations of
569 replicable genetic material obtained through the use of modern biotechnology.

570 **Figure 1 – In vitro nucleic acid techniques**



573 LMOs can also be produced through cell fusion where cells from two different organisms that do not
574 belong to the same taxonomic family are fused resulting in an organism containing the genetic
575 information from both parental cells. The resulting LMO may contain the complete genomes of the
576 parental organisms or parts of their genomes. Cell fusion can be applied to bacterial, fungal, plant or
577 animal cells, using a variety of techniques to promote fusion.

578 *Commonly used methods for genetic modification of plants*

579 Production of LMOs through genetic modification is a multistage process that can be achieved through a
580 variety of methodologies. Methods that are commonly used in the development of LM plants can be
581 summarized as follows:¹⁰

¹⁰ Adapted from IUCN (2003).

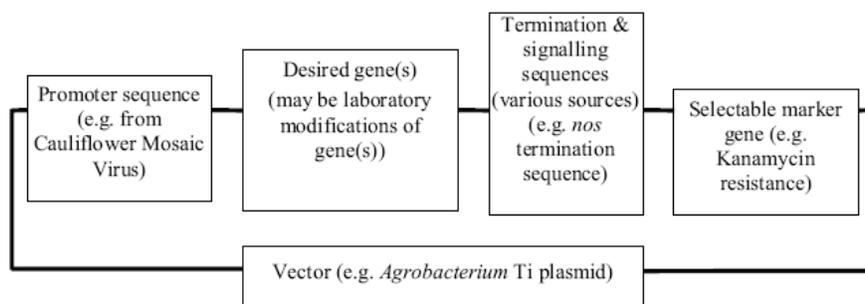
- 582 • Once a gene of interest has been identified and isolated from a donor organism, it is manipulated
583 in the laboratory such that it can be inserted effectively into the intended recipient organism. The
584 manipulation may, for example, include changes to the sequence of nucleotides so as to enhance
585 or modulate the expression of the gene once it is introduced into the intended recipient organism.

- 586 • One or more genes of interest, as well as other nucleotide sequences needed for the proper
587 functioning of the gene(s) of interest, may then be built in an orderly sequence into a
588 “transformation cassette”,¹¹ as shown in figure 2. The transformation cassette typically includes a
589 “promoter sequence” and “termination sequence” which are necessary to ensure that the gene is
590 expressed correctly in the recipient organism. Different promoter sequences control gene
591 expression in different ways; some allow the continuous expression of the gene (these promoters
592 are known as “constitutive”), while others switch the expression of the gene on or off in different
593 tissues, organs and/or developmental stages of the organism or in reaction to other external
594 influences. Some promoters may be highly specific to the point that they regulate gene expression
595 only in a few cells of the organism and during short, specific developmental stages.

- 596 • A “marker gene” is often incorporated into the transformation cassette to help identify and/or
597 select cells or individuals in which the transformation cassette(s) was successfully introduced.
598 Marker genes may, in some cases, be removed from the LMOs at a later stage. identify or select
599 cells or organisms.

- 600 • Finally, the transformation cassette may be incorporated into a larger DNA molecule to be used
601 as vector.¹² The purpose of the vector is to assist the transfer of the transformation cassette into
602 the recipient organism.

603 **Figure 2 – Scheme of a transformation cassette and vector**



604
605 Note: Transformation cassettes currently used may include multiple elements – for example, several
606 promoter sequences and desired genes.

607 *Source: IUCN (2003).*

¹¹ A transformation cassette comprises a group of DNA sequences (e.g., parts of a vector and one or more of the following: a promoter, the coding sequence of a gene, a terminator, other regulatory sequences), which are physically linked and often originated from different donor organisms. The transformation cassette is integrated into the genome of a recipient organism through methods of modern biotechnology to produce an LMO. A transformation cassette may also be called “expression cassette” (mainly when a specific expression pattern is aimed at), “DNA cassette” or “gene construct”.

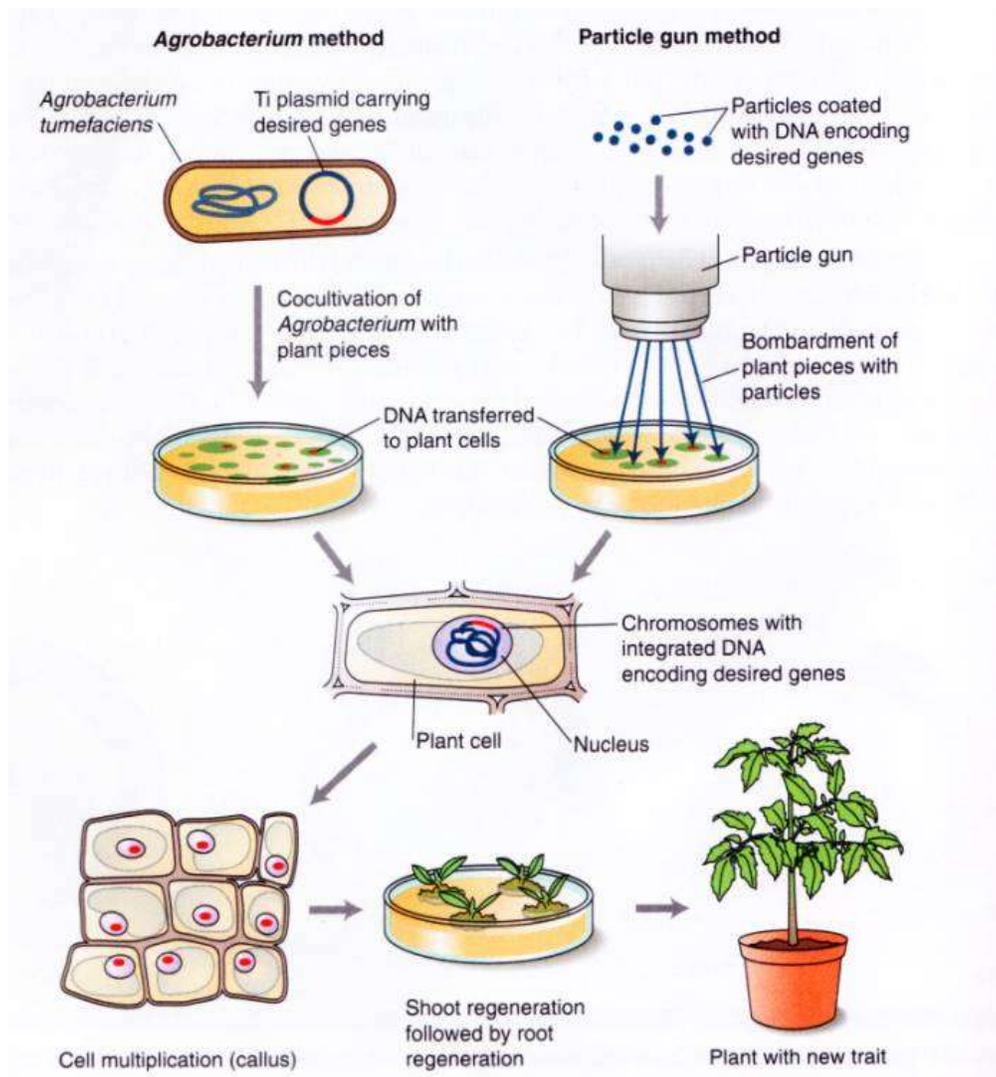
¹² In the context of genetic modification, a vector is an organism (e.g., virus) or a DNA molecule (e.g., plasmid, nucleic acid cassettes) used to assist the transfer of genetic material from a donor organism to a recipient organism.

608 The transformation cassettes are integrated into the genome of the recipient organism through a process
609 known as transformation, as outlined in figure 3. This can be carried out through different methods such
610 as infection using *Agrobacterium*, particle bombardment or microinjection.

611 Transformed cells are then selected, e.g. with the help of a marker gene, and regenerated into complete
612 LMOs. The subsequent step is the further selection of the modified organisms that contain the desired
613 transgene(s)¹³ or modification, and express the desired characteristics. Through selection, many
614 experimental LMOs are discarded and only a few events may reach the stage of commercialization.

615 In the case of LM plants, cross-breeding to introduce the transgene(s) into other recipient varieties is also
616 common.

617 **Figure 3 – Genetic modification of plants**



618
619 **Source: Mirkov (2003).**

¹³ A nucleic acid sequence in an LMO that results from the application of modern biotechnology as described in Article 3 (i) (a) of the Protocol.

620 ***Examples of commercialized LMOs***

621 In 1978, the first commercialized LMO was produced with the creation of an *Escherichia coli* strain (a
622 bacteria) that produces the human protein, insulin. In 1996, the first genetically modified seeds were
623 planted in the United States for commercial use.¹⁴

624 To date, the most broadly commercialized LMOs introduced into the environment are agricultural crops.
625 According to the International Service for the Acquisition of Agri-biotech Applications (ISAAA), the
626 worldwide area cultivated with LM crops has been growing steadily since 1996, and in 2009, the
627 cultivation of LM crops accounted for 170 million hectares (James, 2012). Soy, maize, cotton, and
628 rapeseed that are resistant to herbicides and/or able to produce pesticidal proteins account for the majority
629 of LM crops being currently commercialized (see LMO Registry in the Biosafety-Clearing House at
630 <http://bch.cbd.int/database/lmo-registry>).

631 In 2009, a goat that produces an anticoagulant drug for humans was the first LM animal to be approved
632 for commercial production.¹⁵ Zebra fish containing fluorescent protein genes are another example of LM
633 animals on the market. Moreover, a number of LM vaccines for humans and animals have been
634 commercialized.

635 To date, there are no examples of the commercialization of LMOs resulting from cell fusion.

636

¹⁴ FLAVR SAVR™ Tomato by Calgene Inc.

¹⁵ <http://www.gtc-bio.com/atryn-antithrombin-recombinant>.

637 **Module 2:**
638 **Preparatory Work – Understanding the**
639 **context in which a risk assessment will be**
640 **carried out**

641

642

643

644

645

646

647

648

649

650

651

652

653

654

655

656

657

658

659

660

661

662

663

664

665

666

667

668

669

(This page was intentionally left blank)

670 **Contents of this module**

671	Introduction
672	National context
673	National protection goals and assessment endpoints
674	National Biosafety Framework
675	Competent National Authorities
676	Practices and principles
677	Other national and international obligations
678	Expert advice and the roles of the risk assessor(s)
679	Scientific advisory body
680	Responsibilities of the risk assessor(s)
681	Roster of Experts on Biosafety
682	Stakeholder participation
683	References
684	

685

686

687

688

689

690

691

692

693

694

695

696

697

698

699

700

701

702

703

704

705

706

707

708

709

710

711

712

(This page was intentionally left blank)

713 **Using this module**

714 This module aims at assisting risk assessors in setting the stage for a risk assessment to be carried out in a
715 scientifically sound and transparent manner, and on a case-by-case basis. While Module 1 addressed the
716 broader context of biosafety, Module 2 addresses the context of specific risks assessments.

717 It highlights the importance of understanding how national policies and international obligations provide
718 overarching guidance for the process. A risk assessor should be familiar with national regulatory and
719 administrative frameworks, including national risk assessment practices, general principles and various
720 obligations, since they establish the legal context for any risk assessment conducted by a national
721 authority.

722 This module describes the relationship between national policies that establish protection goals,
723 regulatory requirements and risk assessment processes that would be compliant with the Cartagena
724 Protocol on Biosafety. It also provides elements to facilitate the understanding of the mandate of risk
725 assessors and the multidisciplinary nature of the risk assessment process.

726 **Introduction**

727 Prior to receiving an LMO notification, risk assessors¹⁶ may need to familiarise themselves with issues
728 such as environmental protection goals, regulatory requirements and compliance of a national framework
729 with the Protocol to gain an understanding of the general framework within which the risk assessment
730 must be carried out to comply with international obligations, national laws and administrative procedures.

731 The biosafety framework of each country may address administrative matters by establishing mechanisms
732 for (i) the selection of risk assessors and/or establishment of advisory bodies; (ii) handling confidential
733 information (Article 21); (iii) public awareness and participation (Article 23); and (iv) if and how socio-
734 economic considerations should be taken into account in the decision-making process (Article 26),
735 amongst other things. The following sections of this module provide an overview on how some issues
736 might be considered by risk assessors prior to undertaking a risk assessment.

737 **National context**

738 *National protection goals and assessment endpoints*

739 Countries are sovereign in setting their own goals such as the protection of the environment, biodiversity
740 or the health of their citizens. In so doing, they often adopt environmental and public health strategies as
741 part of their national policy and legislation. These strategies, in turn, are often derived from, or compliant
742 with, broader internationally agreed instruments.

¹⁶ For the purposes of this training material, the term “risk assessor” refers to an individual mandated by a Competent National Authority (CNA) to conduct and manage the risk assessment process.

743 Environmental and health policies and laws often define sets of “protection goals”, which are defined and
744 valued environmental outcomes that guide the formulation of strategies for the management of activities
745 that may affect the environment. Some protection goals are defined broadly (e.g. conservation of
746 biodiversity) while others are more specific (e.g. protection of a threatened or endangered species). The
747 context for all (environmental) risk assessments is set by the relevant protection goals, regardless of
748 whether they are broad or specific.

749 ***Example 3: Protection goals – Aichi Biodiversity Targets***

750 ► Strategic Goal A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity
751 across government and society

752 ► Strategic Goal B: Reduce the direct pressures on biodiversity and promote sustainable use

753 ► Strategic Goal C: To improve the status of biodiversity by safeguarding ecosystems, species and
754 genetic diversity

755 ► Strategic Goal D: Enhance the benefits to all from biodiversity and ecosystem services

756 ► Strategic Goal E: Enhance implementation through participatory planning, knowledge management
757 and capacity building

758 *Source:* Convention on Biological Diversity (website)

759

760 ***Example 4 – Biodiversity protection goal in the European Union***

761 “To halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, restore
762 them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss.”

763 *Source:* Council of the European Union (2010).

764 In addition to the protection goals, national legislations sometimes also define “assessment endpoints”.
765 An assessment endpoint is an explicit expression of the environmental value that is to be protected,
766 operationally defined as an entity (such as salmon or honeybees, soil quality) and its attributes (such as
767 their abundance, distribution or mortality).

768 Ecological assessment endpoints, for instance, are most easily expressed in terms of impacts on a valued
769 species (e.g. survival and reproduction of the yellow fin tuna). Any component, from virtually any level
770 of biological organization or structural form that is recognized as an entity that needs to be protected, can
771 be considered an assessment endpoint.

772 ***Example 5 – Assessment endpoints***

773 “An assessment endpoint is an explicit expression of the environmental value to be protected,
774 operationally defined as an ecological entity and its attributes.”

775 *Source:* US Environmental Protection Agency (1998).

776 Once a risk assessment has been triggered, the risk assessor(s) will need to identify the relevant protection
777 goals and assessment endpoints when these are available. The risk assessor(s) then determines which
778 assessment endpoints are meaningful to the specific case at hand to ensure that the protection goals will
779 be adequately covered. For example, the regulatory framework of a country may identify “agricultural
780 biodiversity” as one of its protection goals and the risk assessor(s) may be asked to consider, as an
781 assessment endpoint, the abundance of a valued species, for example an insect pollinator, in the
782 environment where the LMO may be released.

783 Selecting endpoints is among the most critical aspects when preparing a conceptual model for the risk
784 assessment as it contributes to setting the stage for the risk assessment and the remaining steps of the
785 process. In conclusion, before undertaking a risk assessment of an LMO, risk assessors and other biosafety
786 officers should understand national protection goals and the importance of deciding upon relevant
787 assessment endpoints in order to plan a risk assessment. Issues related to protection goals and relevant
788 assessment endpoints are outlined in more detail in Module 3 under “Planning phase”.

789 *National Biosafety Framework*

790 Many countries address biosafety related issues through a large process that includes the development and
791 implementation of a National Biosafety Framework (NBF). An NBF consists of a combination of policy,
792 legal, administrative and technical instruments that are set in place to address the safety of the
793 environment and human health in relation to modern biotechnology.

794 In most cases, the administration of biosafety responsibilities is either shared by several government
795 departments (e.g. environment, agriculture, health, science) or centralized and managed by one office
796 which is responsible for the coordination of biosafety issues over a number of government departments.

797 The choice of framework most often reflects existing regulatory structures and the resources available at
798 the national level for implementing the biosafety regulations.

799 There has been a significant increase in the number of countries that possess NBFs. A global initiative
800 funded by the Global Environment Facility (GEF) and its implementing agencies helped this process by
801 providing administrative and technical assistance to countries for developing and implementing their
802 NBFs in accordance with their obligations under the Cartagena Protocol.

803 Countries’ requirements and priorities resulted in the development of national biosafety policies in a
804 variety of forms. Some choose to develop a stand-alone policy on biosafety, whilst others formulated
805 combined policies on biotechnology and biosafety. Some policies are part of wider policies on
806 biodiversity conservation and environmental protection, trade related issues, biosecurity and quarantine,
807 or established within the overall context of sustainable development or Agenda 21 (UNCED, 1992).

808 As of May 2012, through the GEF funded initiatives, 121 developing countries have completed the
809 development phase of their National Biosafety Frameworks and made them available online.¹⁷

810 ***Competent National Authorities***

811 While the NBFs consist of policy, legal, administrative and technical instruments, the institutional
812 responsibility for decision-making and for risk assessments of LMOs usually falls to the Competent
813 National Authorities (CNAs). According to the Cartagena Protocol, each Party is to designate one or more
814 CNAs to perform the administrative functions required by the Protocol.

815 Additionally, according to the Protocol, Parties are obliged to clearly indicate, through the Biosafety
816 Clearing-House (BCH), any existing laws, regulations or guidelines for implementation of the Protocol,
817 as well as the names and addresses of its CNA(s).¹⁸

818 The NBFs usually set out competencies and procedures depending on the LMO (e.g. the type of LMO or
819 its intended use). As such, risk assessments may be assigned to different CNAs within the same country.

820 ***Example 6 – Competent National Authorities in Mexico***

821 In Mexico, for instance, depending on the LMO and its intended use, one or more of its CNAs (Ministry
822 of Health, Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food, and Ministry of
823 Environment and Natural Resources) may be responsible for the risk assessment.

824 *Source:* Biosafety Clearing-House.

825 The options chosen by countries for the institutional setup of CNAs in each NBF include (i) a single CNA
826 receiving and processing all requests regarding LMOs, or (ii) more than one CNA, each with different
827 responsibilities and with either a single or multiple routes for the submission of applications regarding
828 LMOs.

829 In cases when a Party designates more than one CNA, information on their respective responsibilities
830 should be clearly stated and made available to the BCH. This information may include, for instance,
831 which CNA is responsible for which type of LMO.

832 In most of the draft NBFs, developed by countries assisted by the UN Environment Programme (UNEP)
833 as a GEF implementing agency, the responsibility of risk assessment has been assigned to the CNA(s) or
834 the overall biosafety body, with or without advice from either an *ad hoc* scientific advisory body, or an
835 established advisory committee.

¹⁷ See <http://www.unep.org/biosafety/National%20Biosafety%20frameworks.aspx>. A large number of the adopted or draft NBFs are also available on the BCH under the 'Laws and Regulations' section.

¹⁸ Laws, regulations and guidelines, as well as CNAs' contact details and other national information requested by the Cartagena Protocol can be accessed through the menu "Country Profiles" available in the BCH at <http://bch.cbd.int>.

836 ***Example 7 – Competent National Authority(ies) and National Biosafety Frameworks***

837 While the competent national authority (or authorities) is responsible for carrying out administrative
838 functions under the Protocol vis-à-vis other Parties, the decision-making process under a Party's national
839 biosafety framework for reaching a decision on the proposed import of an LMO is likely to involve a
840 wide range of national authorities. The national biosafety framework should set out the domestic level
841 procedure, including any necessary consultations, by which any decision on a proposed import will be
842 taken.

843 *Source:* IUCN (2003).

844 National Biosafety Frameworks, when established, define the conditions that trigger the need for a risk
845 assessment. Without prejudice to any right of a country to subject all living modified organisms to a risk
846 assessment, under the Cartagena Protocol two specific cases require mandatory risk assessments prior to
847 making a decision: a) the first intentional transboundary movement of a living modified organism for
848 intentional introduction into the environment of the Party of import, and b) a final decision regarding the
849 domestic use of a living modified organism, including its placement on the market, that may be subject to
850 transboundary movement for direct use as food or feed, or for processing.

851 Upon receiving a request that triggers a risk assessment, the CNA takes several actions as part of a
852 process to ensure that a scientifically sound risk assessment is carried out by risk assessors. These may
853 include the following:

- 854 (a) Reviewing the LMO notification for completeness against a pre-determined list of information;¹⁹
- 855 (b) Specifying the terms of reference of the risk assessment and the information expected in the final
856 report;
- 857 (c) Identifying one or more risk assessors who will conduct and manage the risk assessment.

858 ***Example 8 – Institutional responsibilities for risk assessment***

859 **Albania** – the National Biosafety Committee makes decisions, being advised by Scientific Commission
860 of the National Biosafety Committee. The scientific committee shall consist of seven members. The
861 members of the scientific committee will be experts from the field of microbiology, genetics, medicine,
862 biochemistry and molecular biology, pharmacy, agriculture, veterinary science, biotechnology and safety
863 at work.

864 **Caribbean** – The CNA is assisted in its work by a Scientific Advisory Committee, which is responsible
865 for conducting risk assessment. In Grenada and the Bahamas, risk assessment is done by the national
866 biosafety coordinating body. In addition to the Scientific Advisory Committee, St. Lucia's National

¹⁹ In case of a notification for transboundary movement to countries that are Parties to the Cartagena Protocol this list shall contain at a minimum the information specified in Annex I (in case of an application for the intentional introduction into the environment) or in Annex II (in case of a decision regarding LMOs intended for direct use as food or feed, or for processing).

867 Competent Authority is supported in its work by a legislated entity called the Biosafety Unit. Staffing of
868 the Unit is also legally constituted and is comprised of the following: biosafety coordinator, information
869 technology specialist, biosafety appraisal officer, public education specialist, administrative secretary and
870 inspectors.

871 **Gambia** – An inter-sectoral National Biosafety Technical Working Group will be established with
872 primary responsibility for risk assessment; decision making will be through the National Biosafety
873 Technical Committee.

874 **Tajikistan** – Risk assessment will be (the responsibility of) an Expert Board under the National
875 Biodiversity and Biosafety Center (NBBC). It will consist of experts from research institutions of
876 Academy of Science, Tajik Academy of Agricultural Science and Ministry for Healthcare. All these
877 subdivisions have a relevant capacity, technical equipment and work experience.

878 **Tonga** – The Director for Department of Environment (the NCA) can specify the means by which
879 scientifically-based risk assessments are to be carried out, and appoint appropriate bodies to undertake
880 risk assessments.

881 *Source: UNEP (2006).*

882 ***Practices and principles***

883 The risk assessment process includes practices and principles that may differ between countries. As seen
884 in Module 1, Annex III of the Protocol lists the general principles for risk assessment. Individual Parties
885 use these general principles to guide the development and implementation of their own national risk
886 assessment process. As such, the general principles for risk assessment may be incorporated into the
887 country's laws, or be included in guidelines adopted by the country.

888 ***Example 9 – Risk assessment practices in various countries***

889 In **Argentina**, once an LM plant has been sufficiently field-tested, the applicant may request that the crop
890 be 'flexibilized,' that is, be approved for unconfined (usually large-scale) planting for certain specified
891 uses. These are: (1) for regulatory purposes – to provide material for analytical, toxicological and other
892 required tests; (2) for export; (3) for off-season seed increase – not to be sold in the country; (4) for tests
893 to be later presented (after approval for commercialization is granted) in support of new variety
894 registration; or (5) for pre-commercial multiplication pending variety registration.

895 In **Canada** the risk assessment audits for plants with novel traits (PNTs, which includes LMOs) are
896 undertaken in offices of the Plant Biosafety Office of the Canadian Food Inspection Agency (CFIA;
897 <http://www.inspection.gc.ca/english/plaveg/bio/pbobbve.shtml>).

898 In **Mexico**, a group of scientists, together with authorities from the Ministry of Agriculture, analyse the
899 applicant's risk assessment on the basis of national legislation. This group may request help from other
900 experts to decide on an application. When the Ministry of Agriculture has become familiar with an LM

901 crop, it may allow the applicant to increase the area planted for the crop, but the applicant will have to
902 continue to present the risk assessment as was done for the first application. Any biosafety measures for a
903 semi-commercial release would also have to be maintained.

904 In **New Zealand**, responsibility for risk assessment lies with the applicant based on the criteria in the
905 legislation. Forms and guides assist applicants understand the intent of the legislative criteria. The
906 Environmental Protection Authority (EPA), formerly “Environmental Risk Management Authority”,
907 evaluates the information provided and if required can seek further expert information or reports as
908 appropriate. Low risk activities that conform to the requirements of the regulatory regime are not publicly
909 notified. Some activities are discretionary for public notification while there are others for which there is
910 a mandatory requirement for public notification (see the EPA website <http://www.epa.govt.nz/>).

911 In the **Philippines** the National Committee on Biosafety for the Philippines audits the risk assessment on
912 LMO activities and calls on the expertise of the Scientific and Technical Review Panel to provide an
913 independent safety audit and recommendations.

914 In **South Africa**, as a general guideline, if scientific reviewers consider a repeat activity of assessed risk
915 to be one that does not differ from an earlier approved activity in terms of the nature of the LMO (host
916 and modified DNA), the applicant, the release environment, the size of the release and the confinement
917 conditions, they will consider a fast track procedure for approval.

918 In the **United Kingdom**, the UK Advisory Committee on Releases to the Environment (ACRE) reviews
919 the safety of LMO activities at the request of Ministers and makes recommendations on whether activities
920 should proceed and what minimum risk management conditions are needed to minimise harm to the
921 environment and human health (see <http://www.defra.gov.uk/acre/about/>).

922 In the **United States**, the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection
923 Service (APHIS; <http://www.aphis.usda.gov>) identifies specific activities where notification only is
924 needed before an activity commences. The regulators review all of these notifications and can request full
925 risk assessment review if they believe the activity differs sufficiently from the familiar to warrant this
926 additional regulation. Risk assessments are audited within APHIS, the Environmental Protection Agency
927 (EPA; <http://www.epa.gov>) and the Food and Drug Administration (FDA; <http://www.fda.gov>) depending
928 on the nature of the LMO and its use.

929 *Source: UNEP-GEF (2005).*

930 ***Other national and international obligations***

931 A country may have national laws and international obligations, such as trade agreements, that are not
932 directly related to biosafety or to the environment but may influence how the risk assessor(s) will proceed
933 once a risk assessment of an LMO is triggered. Such obligations may, for instance, affect establishing the
934 scope of the risk assessment (see Module 3).

935 For examples of relevant international treaties and agreements see Module 1.

936 **Expert advice and the role of the risk assessor(s)**

937 *Scientific advisory body*

938 In some countries the necessary expertise required to carry out risk assessments of LMOs resides in the
939 regulatory agencies and the risk assessments are carried out internally. In such cases, these agencies
940 typically have the option of requesting additional expert input if deemed necessary.

941 On the other hand, the regulatory frameworks of many other countries call for the establishment of
942 scientific expert panels on an *ad hoc* basis once a risk assessment has been triggered. In such cases, a
943 CNA assesses what expertise is needed for each specific case and pools together an external team of risk
944 assessors consisting of experts in the relevant scientific fields. Such an advisory body may contain a pool
945 of experts at the national, regional or international levels, who can be called upon to assist the mandated
946 risk assessor(s) when a need arises. A scientific advisory body allows the CNA to quickly engage the
947 appropriate expertise for a particular risk assessment. In cases when a CNA establishes a team or panel of
948 risk assessors, it typically designates one of the risk assessors to coordinate the risk assessment process.

949 ***Example 10 – How scientists are involved in the risk assessment process***

950 National institutions responsible for a biosafety framework may include, for instance, a scientific advisory
951 body that carries out or reviews a risk assessment and recommends what, if any, risk management
952 measures may be needed to protect the environment and human health.

953 In **Belarus**, experts who will conduct risk assessment will be chosen from a roster of experts that will be
954 adopted by Government. In every case experts will be selected separately.

955 In **Mexico**, the Ministry of Agriculture, one of the CNAs for Biosafety, consults a group of scientists for
956 advice on each request. The Inter-Secretarial Commission on Biosafety of Genetically Modified
957 Organisms (CIBIOGEM, <http://www.cibiogem.gob.mx>) also has a database of 350 experts in different
958 disciplines from whom they can seek advice.

959 In **New Zealand**, in addition to the in house expertise of EPA, an expert science panel of eminent
960 researchers has been established and a roster of experts including overseas experts is maintained and is
961 used as appropriate.

962 In **South Africa**, the regulatory office has a database of over 60 scientists and experts used in risk
963 assessment. However, not all of these experts are needed for every review. The reviewers all sign a
964 confidentiality agreement with the regulators.

965 *Source: UNEP-GEF (2005).*

966

967 ***Responsibilities of the risk assessor(s)***

968 National frameworks establish different types of responsibilities for the risk assessors. These
969 responsibilities are usually specified in the terms of reference for the risk assessment and may include, for
970 example:

- 971 ➤ Review of the information provided in the LMO dossier, and in particular the information in the
972 risk assessment provided by the applicant, if available;
- 973 ➤ Identify any other relevant scientific information on the subject at hand, including previous risk
974 assessments or new information that has come to light;
- 975 ➤ Consider information gaps and scientific uncertainties and possible ways to address them;
- 976 ➤ Conduct the risk assessment and prepare a report.

977 These actions are performed in a process that can be iterative. For example, it is possible that while the
978 risk assessment is being conducted, a new piece of scientific information comes to light and reveals some
979 information gaps that had not been previously identified. In such a case, it may be necessary to identify
980 and engage additional sources of scientific expertise that should be included in the initial risk assessment
981 panel or scientific advisory body.

982 In reviewing the LMO dossier or at any subsequent steps of the risk assessment, the CNA(s) or the risk
983 assessor(s) may decide that further documentation is needed and may choose to request it from the
984 applicant or to conduct or commission their own testing.

985 The risk assessor(s) in charge of leading the process is often responsible for the coordination of the expert
986 panel or risk assessment team. Additionally they report the findings and disseminate relevant documents
987 among other parties involved, including other stakeholders (see below), as appropriate, to ensure that
988 information is shared properly and in a timely manner.

989 Parties to the Protocol shall ensure that they have procedures to protect confidential information as per
990 Article 21 of the Protocol and in accordance with national legislation. As such, the risk assessor(s) is also
991 required to respect any confidential business information indicated by the CNA taking into account that,
992 according to the Protocol, the following information cannot be considered confidential: a) the name and
993 address of the notifier; b) a general description of the living modified organism(s); c) a summary of the
994 risk assessment highlighting the effects of the LMO on the conservation and sustainable use of biological
995 diversity, taking also into account risks to human health; and d) any methods and plans for an emergency
996 response.

997 Once a scientific risk assessment is completed, the risk assessor(s) prepares a risk assessment report in
998 accordance with the terms of reference established by the CNA. The report should be sufficiently detailed
999 to provide the necessary scientific information to the decision makers (see Module 3).

1001 ***Roster of Experts on Biosafety***

1002 To facilitate countries' access to relevant expertise when needed, the Parties to the Cartagena Protocol on
1003 Biosafety established the "Roster of Experts on Biosafety". The aim of this Roster is to "provide advice
1004 and other support, as appropriate and upon request, to developing country Parties and Parties with
1005 economies in transition, to conduct risk assessment, make informed decisions, develop national human
1006 resources and promote institutional strengthening, associated with the transboundary movements of living
1007 modified organisms".

1008 Information on individuals listed in the Roster of Experts on Biosafety is accessible through the BCH at
1009 <http://bch.cbd.int/database/experts>. As of March 2014, the Roster of Experts on Biosafety contained 159
1010 experts from 45 countries.

1011 ***Stakeholder participation***

1012 In the context of risk assessments of LMOs, stakeholders are all those with an interest or stake in
1013 biosafety, i.e. in the safe transfer, handling and use of LMOs in the country (UNEP-GEF, 2003).

1014 While there is no direct mention to stakeholder participation in Article 15 on Risk Assessment of the
1015 Protocol, Article 23 requires that Parties consult the public in the decision-making process regarding an
1016 LMO.

1017 Determining the extent to which the public and other stakeholders may be involved in the decision-
1018 making process is the prerogative of each regulatory framework. Some countries have a mechanism that
1019 enables public participation during the risk assessment and/or decision-making process. For example, one
1020 of the CNAs in New Zealand, the Environmental Protection Agency (EPA, www.epa.govt.nz), opens
1021 LMO notifications to public consultation on its website.

1022 **References**

1023 Convention on Biological Diversity (website) Aichi Biodiversity Targets. Available at
1024 <http://www.cbd.int/sp/targets/> (access December 2013).

1025 Council of the European Union (2010) Press release: 3002nd Council meeting – Environment. Brussels,
1026 15 March 2010. Available at
1027 http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/envir/113373.pdf (access June
1028 2010).

1029 IUCN (2003) An Explanatory Guide to the Cartagena Protocol on Biosafety. Available at
1030 <http://bch.cbd.int/database/record-v4.shtml?documentid=41476> (access June 2010).

- 1031 UNCED (1992) Agenda 21. Rio Declaration on Environment and Development, United Nations
1032 Conference on Environment and Development (UNCED), Rio de Janeiro, Brazil, 3-14 June 1992.
1033 Available at <http://www.un.org/esa/dsd/agenda21> (access June 2010).
- 1034 UNEP (2006) A Comparative Analysis of Experiences and Lessons from the UNEP-GEF Biosafety
1035 Projects. Available at:
1036 http://www.unep.org/biosafety/Documents/UNEPGEFBiosafety_comp_analysisDec2006.pdf (access
1037 May 2010).
- 1038 UNEP-GEF (2003) A Biosafety Framework Development Toolkit - Phase 0: Starting the Project.
1039 Available at:
1040 http://www.unep.ch/biosafety/old_site/development/devdocuments/TOOLKIT%202006%20Phase0.pdf
1041 (access May 2010).
- 1042 UNEP-GEF (2005) A Biosafety Framework Development Toolkit - Phase 3: Drafting the NBF -
1043 Designing the Administrative Systems for Handling Applications and Notification. Available at:
1044 http://www.unep.ch/biosafety/old_site/development/devdocuments/TOOLKIT%202006%20Phase3b.pdf
1045 (access May 2010).
- 1046 US Environmental Protection Agency (1998) Guidelines for Ecological Risk Assessment. EPA/630/R-
1047 95/002F. Available at http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=36512 (access June
1048 2010).
- 1049

1050

1051

1052

1053

1054

1055

1056

1057

1058

1059

1060

1061

1062

1063

1064

1065

1066

1067

1068

1069

1070

1071

1072

1073

1074

1075

1076

1077

(This page was intentionally left blank)

1078

1079

Module 3:

1080

Conducting the Risk Assessment

1081

1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109

(This page was intentionally left blank)

1110	Contents of this module
1111	
1112	Introduction
1113	Overview of the risk assessment methodology
1114	Overarching issues
1115	Quality and relevance of information
1116	Consideration of uncertainties
1117	Planning phase
1118	Establishing the context and scope
1119	Selecting relevant assessment endpoints or representative species
1120	Establishing the baseline
1121	The choice of comparator(s)
1122	Conducting the risk assessment
1123	Step 1: Identification of any novel genotypic and phenotypic characteristics associated with the LMO
1124	that may have adverse effects
1125	Elements of a case-by-case risk assessment of LMOs
1126	Living modified organism
1127	Likely potential receiving environment(s)
1128	Intended use
1129	Step 2: Evaluation of the likelihood
1130	Step 3: Evaluation of the consequences
1131	Step 4: Estimation of the overall risk
1132	Step 5: Identification of risk management and monitoring strategies
1133	Risk management
1134	Monitoring
1135	Preparing a risk assessment report and recommendation
1136	References
1137	
1138	
1139	
1140	
1141	
1142	
1143	
1144	
1145	
1146	
1147	
1148	
1149	
1150	
1151	
1152	
1153	

1154
1155
1156

1157

1158

1159

1160

1161

1162

1163

1164

1165

1166

1167

1168

1169

1170

1171

1172

1173

1174

1175

1176

1177

1178

1179

1180

1181

1182

(This page was intentionally left blank)

1183 **Using this module**

1184 This module provides an overview of the risk assessment methodology. It is structured into five sections.
1185 The first section provides an overview of the general methodology for environmental risk assessment and
1186 reviews some of the terms used. The second section elaborates on issues that are overarching to the entire
1187 risk assessment process, such as the quality and relevance of information needed and considerations of
1188 uncertainty. The third section explains some common actions that are undertaken when setting the context
1189 and scope of the risk assessment. The fourth section discusses the specifics of the process of conducting
1190 the risk assessment, and follows the methodology and steps in Annex III of the Protocol along with a
1191 short description on how risk assessors may proceed in each of these steps. Under Step 1 of this section,
1192 an overview of the elements that form the basis of conducting a scientifically sound risk assessment, on a
1193 case-by-case basis, is provided. For each of these elements, this section also includes the “Points to
1194 consider” as outlined in Annex III of the Protocol, along with a short rationale as to how this information
1195 may be useful. The fifth and final section of this module outlines how to communicate the findings and
1196 conclusions of the risk assessment process, and recommendations as to whether or not the risks are
1197 acceptable or manageable.

1198 It is noted that this module does not replace Annex III, but it aims to assist risk assessors in the practical
1199 use of the concepts contained therein. Any methodology or terminology that is used in this module but
1200 not included in Annex III or in the Protocol does not reflect a particular regulatory approach to risk
1201 assessment of LMOs, but rather draws from a variety of academic and regulatory experiences. As in the
1202 other modules, examples from various approaches to risk assessment are provided in the boxes.

1203 Although many of the principles included in this module are applicable to a wide range of LMOs, this
1204 module focuses primarily on risk assessment of LM plants produced through the application of *in vitro*
1205 nucleic acid techniques, due to the experience available.

1206 **Introduction**

1207 Risk assessments are intended to calculate or estimate the risk to a given target organism, system, or
1208 (sub)population, including the identification of uncertainties, following exposure to a particular agent,
1209 taking into account the inherent characteristics of the agent of concern as well as the characteristics of the
1210 specific target system (WHO, 2004). In the context of biosafety, risk assessment can be defined as the
1211 process of estimating risks that may be associated with an LMO on the basis of what adverse effects may
1212 be caused, how likely the adverse effects are to occur, and the consequences should they occur.

1213 The risk assessment process involves a critical review of available data for the purpose of identifying and
1214 possibly quantifying the risks resulting from, for example, natural events (flooding, extreme weather
1215 events, etc.), technology, agricultural practices, processes, products, agents (chemical, biological,
1216 radiological, etc.) and any activity that may pose threats to ecosystems, animals and/or people.

1217 The objective of a risk assessment under the Cartagena Protocol “is to identify and evaluate the potential
1218 adverse effects of living modified organisms on the conservation and sustainable use of biological
1219 diversity in the likely potential receiving environment, taking also into account risks to human health”
1220 (Annex III).

1221 The results of risk assessments of living modified organisms (LMOs) are typically used by decision-
1222 makers to make informed decisions regarding the approval, with or without conditions (e.g. requirements
1223 for risk management and monitoring strategies), or prohibition of a certain use of the LMO.

1224 This module provides an introduction to risk assessment and considerations that may assist risk assessors
1225 in conducting risk assessments of LMOs that are consistent with Article 15 and Annex III of the Protocol.
1226 ²⁰

1227 **Overview of the risk assessment methodology**

1228 In order to understand what is meant by risk assessment it is important to be familiar with the concepts of
1229 *risk* and *hazard*, and how these terms differ. The term “risk” does not have a single unambiguous
1230 definition but it is often defined as “the probability of harm”. This is broadly understood as the likelihood
1231 that a harmful consequence will occur as the result of an action or condition.

1232 **Figure 4 – Assessing risks**



1233
1234 Source: http://www.scienceinthebox.com/en_UK/safety/riskassessment_en.html .

1235

²⁰ Taking into consideration the experience available, the focus of this training module will be LMOs produced through the application of *in vitro* nucleic acid techniques (i.e. produced through genetic transformation) and not on LMOs produced through cell fusion beyond the taxonomic family (see Article 3 of the Protocol).

1236 Risk is often assessed through the combined evaluation of hazard and exposure.

- 1237
- 1238
- 1239
- 1240
- 1241
- 1242
- “*Hazard*”, in the context of LMO risk assessment, is defined as the potential of an organism to cause harm to human health and/or the environment (UNEP, 1995).
 - “*Exposure*” means the contact between a hazard and a receptor. Contact takes place at an exposure surface over an exposure period (WHO, 2004). In the risk assessment of LMOs, “exposure” can be understood as the route and level of contact between the likely potential receiving environment and the LMO or its products.

1243 The exposure pathway from the hazard to the receptor and the possible exposure scenarios²¹ form
1244 important additional elements in understanding risk. Ascribing the probability and consequences of
1245 exposure of a receptor to the hazard characterizes the risk. All these elements must be evaluated to form
1246 an effective and useful risk assessment for specific scenarios (UNEP Division of Technology, Industry
1247 and Economics).

1248 A simple example can be used to distinguish hazard from risk: acids may be corrosive or irritant (i.e. a
1249 hazard) to human beings. The same acid is a risk to human health only if humans are exposed to it
1250 without protection. Thus, the degree of harm caused by the exposure will depend on the specific exposure
1251 scenario. If a human only comes into contact with the acid after it has been heavily diluted, the risk of
1252 harm will be minimal but the hazardous property of the chemical will remain unchanged (EEA, 1998).

1253 ***Example 11 – What is risk? What is Risk Assessment?***

1254 Risk: the combination of the magnitude of the consequences of a hazard, if it occurs, and the likelihood
1255 that the consequences will occur.

1256 Risk assessment: the measures to estimate what harm might be caused, how likely it would be to occur
1257 and the scale of the estimated damage.

1258 *Source: UNEP (1995).*

1259 Risk assessment of LMOs can be divided into four main phases (WHO, 2004):

- 1260
- 1261
- 1262
- 1263
- 1264
- 1265
- 1266
- 1267
- (a) *Hazard identification* – The identification of the type and nature of adverse effects that an LMO could cause to an organism, system, or (sub)population.
 - (b) *Hazard characterization* – The qualitative and/or quantitative evaluation of the nature of the adverse effects associated with an LMO.
 - (c) *Exposure assessment* – Evaluation of the exposure of the environment, including organisms, to an LMO or products thereof.
 - (d) *Risk characterization* – The qualitative and/or quantitative estimation, including attendant uncertainties, of the overall risk.

1268 If risks are identified during the *risk characterization* step above, risk management strategies may be
1269 identified which may effectively prevent, control or mitigate the consequences of the adverse effects. As

²¹ “*Exposure scenario*” is a set of conditions or assumptions about sources, exposure pathways, amounts or concentrations of agent(s) involved, and exposed organism, system, or (sub)population (i.e., numbers, characteristics, habits) used to aid in the evaluation and quantification of exposure(s) in a given situation.

1270 such, the risk assessment process often includes an additional step to identify a range of possible risk
1271 management strategies that could reduce the level of risk.

1272 It is worth noting, however, that it is only during the decision-making process that a choice is made as to
1273 whether an identified risk is acceptable and whether or not risk management strategies are to be
1274 implemented (see more details on the identification of risk management strategies under step 5).

1275 As a whole the risk assessment process can be highly iterative; meaning that one or several steps may
1276 need to be re-evaluated when, for instance, new information becomes available in an attempt to increase
1277 the level of certainty.

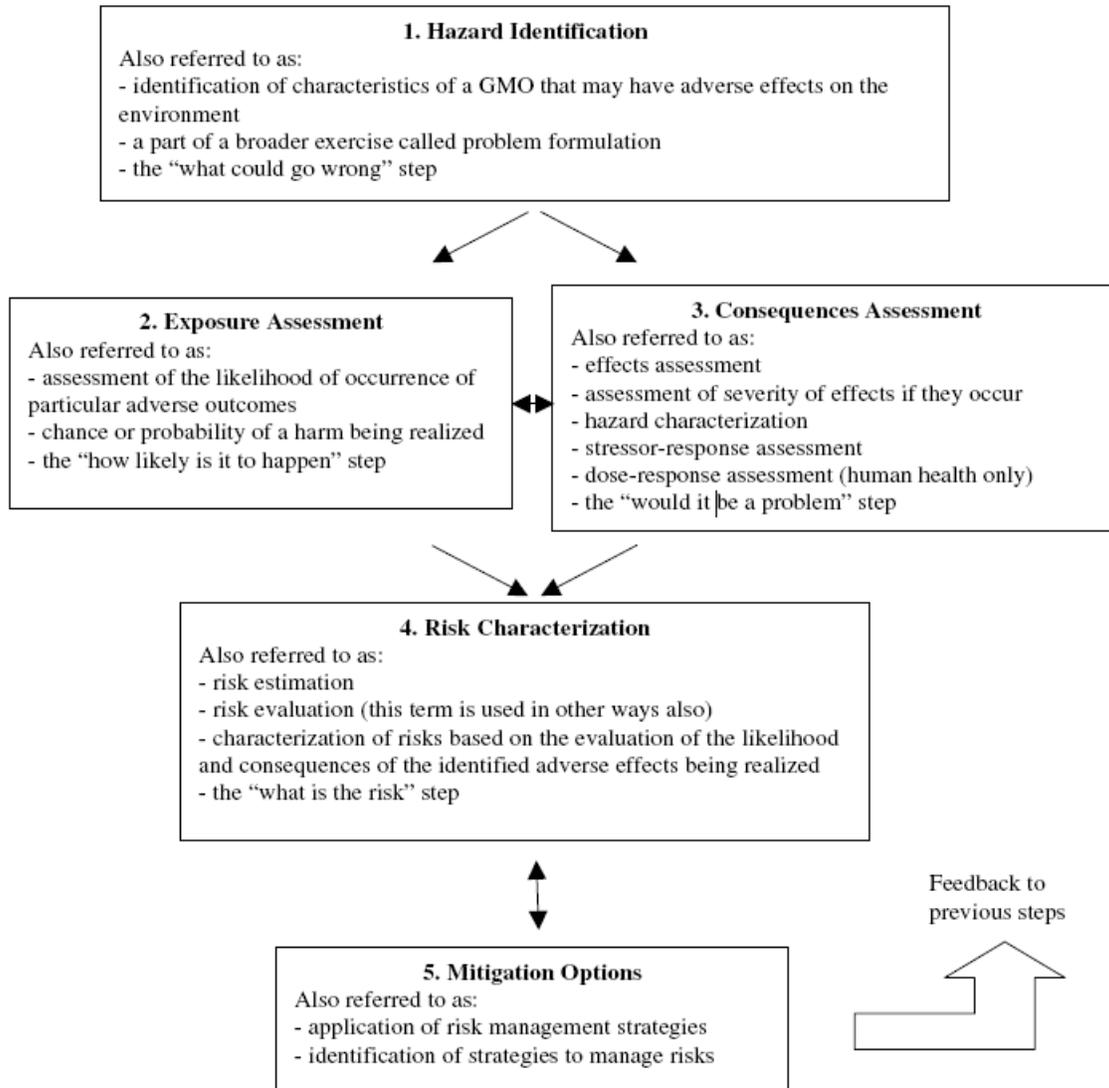
1278 The methodologies for risk assessment of LMOs have evolved over the past few decades. At a conceptual
1279 level, the methodologies have been adapted from the existing paradigms for environmental risk
1280 assessment developed for chemicals and other types of environmental stressors (Hill, 2005). As a result,
1281 the terminology used within each methodology may vary.

1282 Familiarity with the different terms used in risk assessment enables a more direct comparison between the
1283 terminology used in Annex III and different risk assessment frameworks. It will also facilitate the
1284 interpretation of results from different risk assessments, for instance, for the same LMO.

1285

1286
1287

Figure 5 – Variation in terminology used to describe methodological components common to many risk assessment frameworks



1288

1289 *Source: Hill (2005)*

1290 **Overarching issues**

1291 Risk assessors need to identify the information needed to conduct a risk assessment and understand how it
1292 will be used. Using and interpreting existing information, as well as identifying information gaps and
1293 understanding how to deal with scientific uncertainty are important factors during the risk assessment.

1294 *Quality and relevance of information*

1295 Considerations of the quality and relevance of information available for the risk assessment are important
1296 throughout the risk assessment process. Relevant information may be derived from a variety of sources
1297 such as existing scientific literature, experience and outcomes from previous risk assessments, in
1298 particular for the same or similar LMOs introduced in similar receiving environments, as well as new
1299 experimental data such as laboratory experiments (e.g. early tier toxicology testing), confined field
1300 experiments or other scientific observations. The relevance and level of detail of the information needed
1301 may vary from case to case depending on the nature of the modification of the LMO, on its intended use,
1302 and on the scale and duration of the environmental introduction.

1303 Scientifically sound methodologies should be determined and documented for testing any identified risk
1304 scenario. When assessment methods are well described, risk assessors and subsequent reviewers are better
1305 equipped to determine whether the information used was adequate and sufficient for characterizing the
1306 risk.

1307 *Example 12 – Data acquisition, verification, and monitoring*

1308 “The importance of the data acquisition, verification, and monitoring process in the development of
1309 accurate risk assessments has been emphasized. Models, no matter how sophisticated, are simply attempts
1310 to understand processes and codify relationships. Only the reiteration of the predictive (risk assessment)
1311 and experimental (data acquisition, verification, and monitoring) process can bring models close to being
1312 a true picture of reality.”

1313 *Source:* UNEP/IPCS (1994).

1314 *Identification and consideration of uncertainty*

1315 Uncertainty is an inherent and integral element of scientific analysis, and its consideration is undertaken
1316 throughout the whole risk assessment process. The risk assessment methodology as set out by the
1317 Cartagena Protocol states that “where there is uncertainty regarding the level of risk, it may be addressed
1318 by requesting further information on the specific issues of concern or by implementing appropriate risk
1319 management strategies and/or monitoring the living modified organism in the receiving environment”.²²

1320 Although uncertainty may, in some cases, be addressed by requesting additional information, the
1321 necessary information may not always be available or new uncertainties may arise as a result of the
1322 provision of additional experimental data. The golden rule during the risk assessment of an LMO is to
1323 request additional information that is relevant to the overall evaluation of risk and will facilitate the
1324 decision making. Thus, it is important to consider and analyze, in a systematic way, the various forms of
1325 uncertainty (e.g. types and sources) that can arise at each step of the risk assessment process.

1326 Uncertainties may arise from: (i) lack of information, (ii) incomplete knowledge, and (iii) biological or
1327 experimental variability, for example, due to inherent heterogeneity in the population being studied or to
1328 variations in the analytical assays. Uncertainty resulting from lack of information includes, for example,
1329 information that is missing and data that is imprecise or inaccurate (e.g., due to study designs, model
1330 systems and analytical methods used to generate, evaluate and analyse the information) (SCBD, 2012).

²² Paragraph 8(f) of Annex III.

1331 If the level of uncertainty changes during the risk assessment process (e.g. by provision of new
1332 information), an iteration of parts or the entire risk assessment process may be needed.

1333 It is important to note that while scientific uncertainty is considered during the risk assessment process
1334 and the results of uncertainty considerations may be reported it is, ultimately, the responsibility of the
1335 decision-makers to decide how to use the information in conjunction with the principals of the
1336 precautionary approach when making a decision on an LMO.

1337 ***Example 13 – Scientific uncertainty***

1338 “There is no internationally agreed definition of ‘scientific uncertainty’, nor are there internationally
1339 agreed general rules or guidelines to determine its occurrence. Those matters are thus dealt with –
1340 sometimes differently – in each international instrument incorporating precautionary measures.”

1341 *Source: IUCN (2003).*

1342 **Planning phase**

1343 ***Establishing the context and scope***

1344 When the regulatory process of a country triggers the need for a risk assessment, it usually results in a
1345 request from the competent authority to the risk assessor(s). This request includes the scope of the risk
1346 assessment to be carried out as well as some important elements that will set the context of the risk
1347 assessment. In a typical case-by-case scenario, in accordance with the Cartagena Protocol, these elements
1348 will include at a minimum: the LMO(s), its(their) specific use(s) and, in cases of introduction into the
1349 environment, the likely potential receiving environment(s) where the LMO may be released and establish
1350 itself. As such, the case-by-case approach does not allow an existing risk assessment to be applied “as is”
1351 to different LMOs, uses or receiving environments. Nevertheless, a risk assessment carried out on a case-
1352 by-case basis most often takes into account relevant knowledge and experience gained in previous risk
1353 assessments.

1354 In practice, if a risk assessor is faced with a request by the Competent National Authorities (CNA) to
1355 conduct or review a risk assessment that does not follow the case-by-case principle, the risk assessor
1356 recommends to the CNA that a new risk assessment be carried out with a scope that is specific to the case
1357 under consideration (i.e. the LMO, its specific use and the likely potential receiving environment).

1358 Protection goals for the conservation and sustainable use of biodiversity, may be defined in national,
1359 regional and international policies. In setting the context of a risk assessment, these goals may be relevant
1360 to the identification and selection of appropriate assessment endpoints and to determining which
1361 methodology will be used in the risk assessment process. Understanding the contribution of national,
1362 regional and regulatory policies in setting the context of the risk assessment is part of the preparatory
1363 work for a risk assessment as seen in Module 2.

1364 After consideration of the protection goals, the risk assessment of a particular LMO proceeds to
1365 establishing the scope in order to define the extent and the limits of the risk assessment process. This
1366 phase usually consists of at least three main actions: (i) selecting relevant assessment endpoints or
1367 representative species on which to assess potential adverse effects; (ii) establishing baseline information;
1368 and (iii) when possible, establishing the appropriate comparator(s).

1369 Although these actions are described here as separate activities, in practical terms, this is an iterative
 1370 process where the risk assessors will usually draw on the results of each action to inform the subsequent
 1371 actions until all their elements have been considered sufficiently enough to enable the risk assessment to
 1372 proceed.

1373 *Selecting relevant assessment endpoints or representative species*

1374 The purpose of an assessment endpoint or of representative species is to provide a measure that will
 1375 indicate whether or not the LMO may cause an adverse impact on a protection goal. In order to be useful,
 1376 the selected assessment endpoints or characteristics of the representative species should be specific and
 1377 measurable.

1378 Assessment endpoints or species representative of important ecological functions²³ or roles should be
 1379 selected on a case-by-case basis. The complexity of ecosystems and the large number of potential
 1380 candidates add to the challenges in selecting the appropriate assessment endpoints in ecological systems.
 1381 Some important criteria for the selection of assessment endpoints to be used in the risk assessment of
 1382 LMOs may include, for example: (i) their relevance to the protection goals; (ii) a well-defined ecological
 1383 function; (iii) accessibility to measurement; and (iv) level of potential exposure to the LMO.

1384 Identifying assessment endpoints or representative species that are relevant within the context of the
 1385 likely potential receiving environment allows the risk assessor(s) to focus on interactions that are likely to
 1386 occur. Moreover, risk scenarios may be also formulated to include assessment endpoints or representative
 1387 species that are not present in the likely potential receiving environment but may, nevertheless, be
 1388 indirectly exposed to the LMOs. This could occur, for example, if a third species, which is sexually
 1389 compatible with the LMO and the representative species, has a distribution area that overlaps with the
 1390 distribution areas of the former two providing an indirect exposure pathway between them.

Example 14 – Common problems in selecting assessment endpoints

- Endpoint is a goal (e.g., maintain and restore endemic populations);
- Endpoint is vague (e.g., estuarine integrity instead of abundance and distribution of a species);
- Ecological entity may not be as sensitive to the stressor;
- Ecological entity is not exposed to the stressor (e.g., using insectivorous birds for avian risk of pesticide application to seeds);
- Ecological entities are irrelevant to the assessment (e.g., lake fish in salmon stream);
- Importance of a species or attributes of an ecosystem are not fully considered;
- Attribute is not sufficiently sensitive for detecting important effects (e.g., survival compared with recruitment for endangered species).

Source: US Environmental Protection Agency (1998).

1391

²³ “Ecological function” is the role of an organism in ecological processes. The relevance of specific ecological functions in the risk assessment will depend on the protection goals. For example, organisms may be part of the decomposer network playing an important role in nutrient cycling in soils, or may be important as a pollen source for pollinators and pollen feeders.

1392

Example 15 – Questions asked when selecting representative species for assessing effects of Bt plants on non-target organisms

- Which variant of the Bt protein are we dealing with?
- Where is it expressed (in the leaves, pollen or only in the roots)?
- Is it produced in the plant throughout its life or only during particular growth phases?
- Which insects come into contact with the Bt protein?
- Is this contact direct and long-term or only occasional?
- Which insects ingest the Bt protein through their prey?

Source: GMO Safety (website).

1393 ***Establishing the baseline***

1394 In risk assessment, the baseline is a description or a measurement of existing conditions of an
1395 environment, or its attributes or components without the LMO under consideration and taking into
1396 account different practices in use (e.g., agricultural practices). The baseline description or measurement
1397 may provide quantitative (e.g., number of organisms, variability of abundance) and/or qualitative
1398 information about the receiving environment as a reference for estimating effects of the LMO or its use
1399 including, if applicable, information on the assessment endpoints. Baselines can refer to, for instance, a
1400 particular environment or health conditions of a population.

1401 Baselines are established with the aim of having descriptive and/or measurable information on any
1402 element of the likely potential receiving environment that is considered relevant in assessing the impacts
1403 from the introduction of the LMO, including considerations on possible impacts on human health.

1404 In practice, if relevant assessment endpoints or representative species are selected, the baseline data will
1405 consist of data that establishes the conditions of these endpoints or species before the introduction of the
1406 LMO in question.

1407 ***The choice of comparators***

1408 As seen above, a comparative approach is one of the general principles of risk assessment as set out in
1409 Annex III to the Protocol, where risks associated with the LMO “should be considered in the context of
1410 the risks posed by the non-modified recipients or parental organisms in the likely potential receiving
1411 environment”.

1412 Using a comparator, i.e. non-modified recipients or parental organisms of the LMOs used as an element
1413 to establish the basis for a comparative assessment in accordance with Annex III, helps a risk assessor to
1414 identify the novel characteristics of the LMO and assess if the LMO presents a greater, lesser or
1415 equivalent risk compared to the non-modified recipient organism that is used in a similar way and in the
1416 same environment.

1417 The ideal comparator is the closest non-modified genotype to the LMO, i.e. (near-)isogenic lines.²⁴
1418 However, (near-)isogenic lines are not always available and the choice of appropriate comparators may be
1419 guided by policies or guidelines adopted by the country undertaking the risk assessment (e.g. EFSA,
1420 2011). Moreover, depending on the context, the step of the risk assessment and question being asked, a
1421 risk assessor may also choose to consider similar or related non-modified genotypes as useful
1422 comparators. Related management practices and experience with similar non-modified organisms may
1423 also be helpful. For example, when considering the risk assessment for an insect resistant LM crop, a risk
1424 assessor may wish to consider, amongst other things, the available experience with pest control practices
1425 applied to non-modified organisms of the same species (e.g. use of spores from *Bacillus thuringiensis* as
1426 pesticides).

1427 In some circumstances, choosing an appropriate comparator(s) can be a challenge. This may happen, for
1428 example, in the case of LM crops that are tolerant to abiotic stress if the non-modified recipient or
1429 parental organisms are not capable of growing in the receiving environment. In extreme situations, when
1430 a suitable comparator cannot be grown under the same conditions and in the same or similar receiving
1431 environment as the LMO, it may be necessary to treat the LMO as a novel species in that environment
1432 (i.e. introduced species). This means that the characterization of the LMO (see below) will focus not only
1433 in the novel genotypic and phenotypic characteristics²⁵ resulting from the genetic modification, but rather
1434 on the characterization of an entire new genotype in the particular receiving environment.

1435 **Conducting the risk assessment**

1436 Conducting the risk assessment involves synthesizing what is known about the LMO, its intended use and
1437 the likely potential receiving environment to establish the likelihood and consequences of potential
1438 adverse effects to biodiversity, taking into account human health, that result from the introduction of an
1439 LMO.

1440 Neither the Protocol nor this Manual makes a distinction between the various types of introductions into
1441 the environment, such as releases for experimental purposes or releases for commercial purposes.
1442 However, the nature and level of detail of the information needed to conduct the risk assessment will vary
1443 depending on the intended use of the LMO (e.g. type of release), the LMO itself and the likely potential
1444 receiving environment.

1445 The following sections will address the steps of the risk assessment methodology described in paragraph
1446 8 of Annex III to the Protocol. These steps describe a structured and integrated process whereby the
1447 results of one step are relevant to subsequent steps. Additionally, the risk assessment process may need to
1448 be conducted in an iterative manner, whereby certain steps may be repeated or re-examined to increase or
1449 re-evaluate the reliability of the risk assessment. If during the process, new information arises that could
1450 change the outcome of a step, the risk assessment may need to be re-examined accordingly.

²⁴ “Isogenic lines” are two or more lines differing from each other genetically at one *locus* only; “near-isogenic” lines are two or more lines differing from each other genetically at several *loci*.

²⁵ “Genotypic characteristics” are those relating to “genotype” as all or part of the genetic constitution of an organism. “Phenotypic characteristics” are those relating to “phenotype” as the observable physical or biochemical characteristics of an organism, as determined by both genetic and environmental factors.

1451 ***Step 1: Identification of any novel genotypic and phenotypic characteristics***
1452 ***associated with the LMO that may have adverse effects***

1453 The first step of the risk assessment is “an identification of any novel genotypic and phenotypic
1454 characteristics associated with the LMO that may have adverse effects on biological diversity in the likely
1455 potential receiving environment, taking into account risks to human health”.²⁶

1456 What constitutes an “adverse effect” (also referred to as “damage” or “harm”) will depend on the context
1457 and scope of the risk assessment taking into account, as appropriate, the specific protection goals as seen
1458 above.

1459 ***Example 16 – Potential adverse effects***

1460 “Harm [potential adverse effect] reflects an undesirable condition involving damage or injury. This
1461 includes change in the morphology, physiology, growth, development, reproduction or life span of an
1462 organism or group of organisms that results in an impairment of functional capacity, an impairment of the
1463 capacity to compensate for additional stress or an increase in susceptibility to other influences. The
1464 perception of harm can vary between people. It can also change over time and differ according to other
1465 factors such as variations in the vulnerability of individuals or type of land use. For example, a cold
1466 medication may be considered harmful if it causes severe side-effects. However, if a cancer drug causes
1467 the same type of side-effects, it may not be considered harmful. Similarly, a plant producing large
1468 amounts of biomass in a pasture may be considered desirable whereas the same plant may be considered
1469 harmful (weedy) in a nature conservation area as it may end up displacing a native species. In addition,
1470 one harmful outcome can sometimes give rise to further downstream harms. For example, increased
1471 harms from weeds, pests or pathogens can lead to loss of biodiversity.”

1472 *Source: OGTR (2013).*

1473

1474 ***Example 17 – Potential risks***

1475 With every new emerging technology, there are potential risks. These include:

- 1476 ▶ The danger of unintentionally introducing allergens and other anti-nutrition factors in foods;
1477 ▶ The likelihood of transgenes escaping from cultivated GM crops into wild relatives;
1478 ▶ The potential for pests to evolve resistance to the toxins produced by GM crops;
1479 ▶ The risk of these toxins affecting non-target organisms.

1480 *Source: GMAC Singapore (website).*

1481

1482

²⁶ Paragraph 8(a) of Annex III.

1483 ***Example 18 – Potential adverse effects from weediness in plants***

- 1484 ▶ Competitive exclusion of other plants;
- 1485 ▶ Reduction in yield/biomass of other plants;
- 1486 ▶ Reduction in quality of products/services;
- 1487 ▶ Restriction of physical movement (e.g. of water, people, animals);
- 1488 ▶ Harm to human and/or animal health;
- 1489 ▶ Altered ecosystem processes (e.g. levels of nitrogen fixation, water supply and use, soil
- 1490 sedimentation or erosion and salt accumulation).

1491 *Source: FAO (2011a).*1492 ***Example 19 – Topics of concern***

1495 According to the International Centre for Genetic Engineering and Biotechnology (ICGEB), the main
 1496 issues of concern derived from the deliberate introduction of LM crops (and their derived products) into
 1497 the environment or onto the market are classified as:

1498 **Risks for animal and human health** – Toxicity & food/feed quality/safety; allergies; pathogen drug
 1499 resistance (antibiotic resistance), impact of selectable marker;

1500 **Risks for the environment** – Persistency of gene or transgene (volunteers, increased fitness of LM crop,
 1501 invasiveness) or of transgene products (accumulative effects); susceptibility of non-target organisms;
 1502 change in use of chemicals in agriculture; unpredictable gene expression or transgene instability (gene
 1503 silencing); environmentally-induced (abiotic) changes in transgene expression; ecological fitness; changes
 1504 to biodiversity (interference of tri-trophic interactions); impact on soil fertility/soil degradation of organic
 1505 material;

1506 **Gene transfer** – Through pollen or seed dispersal & horizontal gene transfer (transgene or promoter
 1507 dispersion); transfer of foreign gene to micro-organisms (DNA uptake) or generation of new live viruses
 1508 by recombination (transcapsidation, complementation, etc.);

1509 **Risks for agriculture** – Resistance/tolerance of target organisms; weeds or superweeds; alteration of
 1510 nutritional value (attractiveness of the organism to pests); change in cost of agriculture; pest/weed
 1511 management; unpredictable variation in active product availability; loss of familiarity/changes in
 1512 agricultural practice.”

1513 *Source: ICGEB (website).*

1514 The genotypic and phenotypic characterization of an LMO provides the basis for identifying differences,
 1515 both intended and unintended, between the LMO and its recipient or parental organism(s). Molecular
 1516 analyses may be performed to characterize the products of the modified genetic elements, as well as of
 1517 other genes that may have been affected by the modification. Data on specific expression patterns may be
 1518 relevant for risk assessment in order to determine exposure, and may also include data confirming the
 1519 absence of gene products, such as RNA and proteins, different from those originally intended. For
 1520 example, in the case where the gene product (i.e. the RNA or protein that results from the expression of a
 1521 gene) is intended to function only in a specific tissue, data may be used to confirm its specificity in that
 1522 tissue and demonstrate its absence in other tissues.

1523 Other phenotypic data are often presented to indicate that the LMO is behaving as anticipated. This could
1524 include data on reproductive characteristics, alterations in susceptibility to pests and diseases or tolerance
1525 to abiotic stressors, etc.

1526 Once the potential adverse effects have been identified, the risk assessment proceeds to estimating the
1527 likelihood and consequences of these effects. To this end, developing risk scenarios may in some cases
1528 provide a useful tool.

1529 A risk scenario may be defined as a sequence of events with an associated probability and consequence.
1530 In the context of risk assessment of LMOs, a risk scenario may be explained as a scientifically
1531 supportable chain of events through which the LMO might have an adverse effect on an assessment
1532 endpoint.

1533 ***Example 20 – A Risk scenario***

1534 “The possibility that growing Bt corn may kill ladybird beetles due to ingestion of the Bt protein when
1535 preying on insects feeding on the GM corn, thereby reducing the abundance of coccinellids in the
1536 agroecosystem and increasing the incidence of pests.”

1537 *Source:* Hokanson and Quemada (2009).

1538 A well-defined risk scenario should be scientifically plausible and allow the assessor to identify
1539 information that is necessary for the assessment of risks.

1540 Although some risk scenarios may appear as obvious (e.g. potential for insect resistant plants to affect
1541 insect herbivore populations), it is always useful to identify the risk scenarios fully. Clear and well-
1542 defined risk scenarios can also contribute to the transparency of a risk assessment because they allow
1543 others to consider whether or not the subsequent steps of the risk assessment have been adequately
1544 performed and facilitate the consideration of possible strategies to manage the identified risks.

1545 A common challenge in generating a well-defined risk scenario is to choose representative species that
1546 would be exposed to the LMO. This is why an exposure assessment should be considered when selecting
1547 assessment endpoints.

1548 When establishing risk scenarios several considerations may be taken into account. These may include: (i)
1549 gene flow followed by introgression of the transgene in species of interest; (ii) toxicity to non-target
1550 organisms; (iii) allergenicity; (iv) multi-trophic interactions and indirect effects; and (v) resistance
1551 development. The following paragraphs explain some of these considerations in more detail:

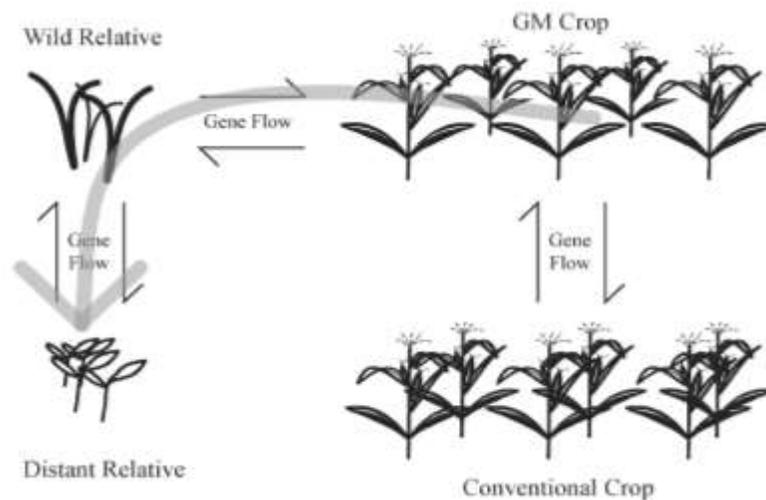
1552 ***Gene flow followed by introgression of the transgene in species of interest*** – “Gene flow” is the transfer
1553 of genetic material from one organism to another by vertical or horizontal gene transfer;²⁷ or the
1554 movement of an organism from one environment to another. In the case of plants, vertical gene flow may
1555 occur even between organisms that are located far apart since pollen can be carried across large distances
1556 by the wind or insects, for instance. “Introgression” is the movement of a gene or genetic element from
1557 one species into the gene pool of another species or population, which may result in a stable incorporation
1558 or some fertile offspring.

²⁷ “Vertical gene transfer” refers to the transfer of genetic material from one organism to its offspring via asexual, parasexual or sexual reproduction. Also referred to as “vertical gene flow”. “Horizontal gene transfer” refers to the transfer of genetic material from one organism to another through means other than inheritance from parent to offspring (i.e., vertical).

1559 Gene flow followed by introgression from an LMO to non-modified organisms may or may not be
1560 considered an adverse effect depending on the protection goals.

1561 The potential for gene flow is first evaluated by investigating if sexually compatible species are present in
1562 the likely potential receiving environment. If sexually compatible species are present, there is a possibility
1563 of gene flow from the LMO to these species. Whether or not the modified genetic elements can
1564 potentially introgress into the population of the sexually compatible species will be largely determined by
1565 the biology of the recipient organism and of the LMO itself (see considerations regarding the likelihood
1566 and consequences of gene flow and introgression in steps 2 and 3).

1567 **Figure 6 – Gene flow to conventional crops and distant relatives through**
1568 **“genetic bridges”**



1569
1570 *Source: Heinemann (2007).*

1571 **Toxicity to non-target organisms** – The potential for an introduced gene product to be toxic to organisms
1572 in the environment is typically addressed by controlled exposure in the environment or by direct toxicity
1573 testing, or by a combination of the two. Non-target organisms may include, for instance, herbivores,
1574 natural enemies (e.g. parasitoids and predators), pollinators and pollen feeders, soil (micro-)organisms
1575 and weeds. The need and extent of toxicity tests will depend on characteristics of the LMO and the level
1576 of exposure of other organisms to the LMO.

1577 If toxicity testing is needed, it typically follows a sequential series of tiered tests. Early tier studies
1578 involve highly controlled laboratory environments where representative or surrogate test species are
1579 exposed to high concentrations of the gene product being studied (i.e. worst case exposures) to determine
1580 if there are any toxic effects. If toxic effects are observed in early tier tests or if unacceptable uncertainty
1581 exists, e.g. regarding effects in multi-throphic interactions (see below), more realistic conditions
1582 representative of field-level exposures can be tested to determine the extent of the risk.

1583 The gene products of the modified genetic elements in LMOs may be produced in very small quantities
1584 thus may be difficult to isolate in the amounts required for toxicity testing. If this is the case, and it is
1585 determined that toxicity tests are required, the risk assessor may consider results from tests using gene
1586 products obtained from alternate (surrogate) sources (e.g. bacterial expression systems or the organism

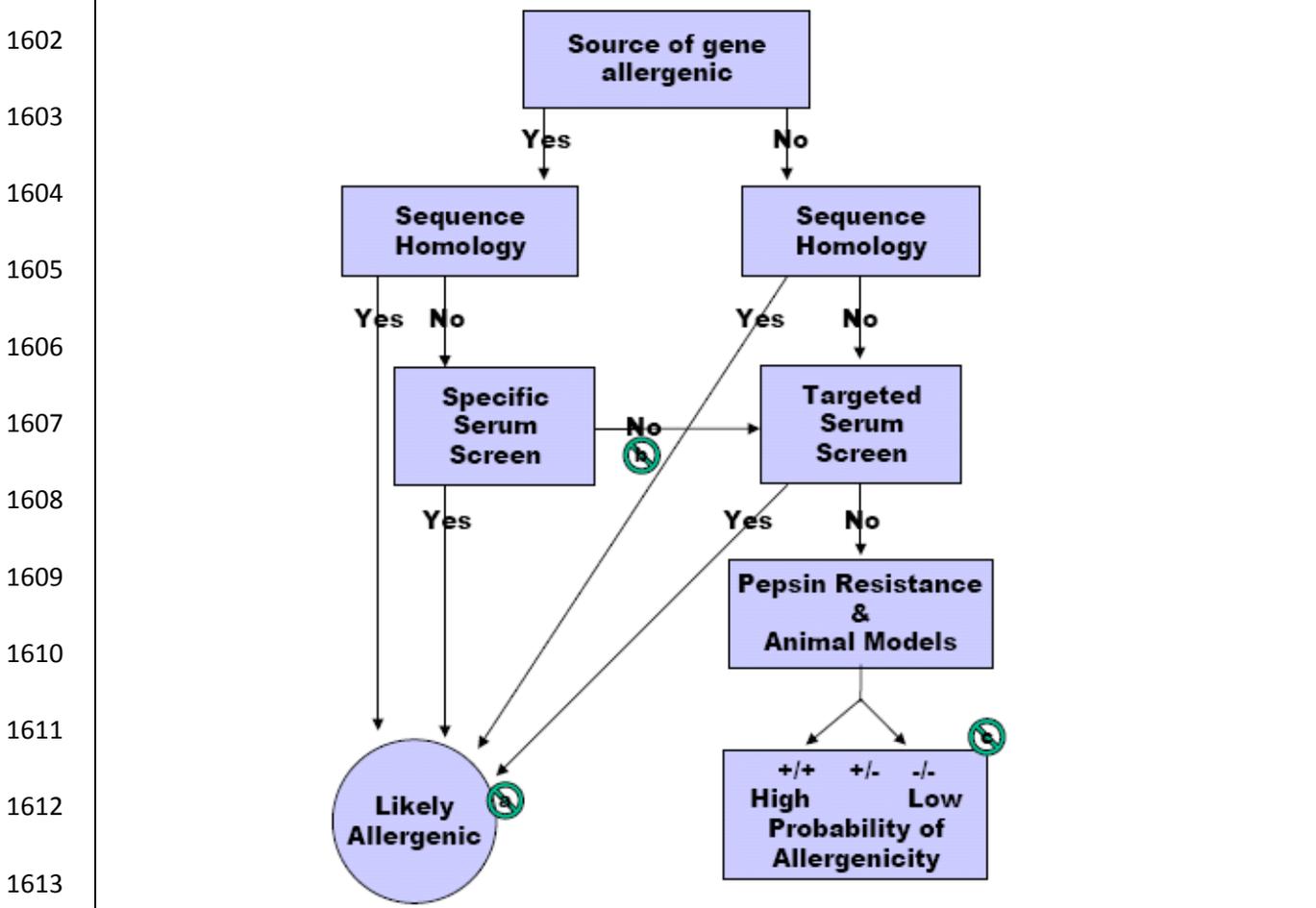
1587 from which the transgene was derived) provided that these gene products are chemically and functionally
1588 equivalent.

1589 **Allergenicity** – Allergies are a type of adverse immunological response that affect individuals who are
1590 predisposed to certain types of substances (i.e. allergens). Allergens are often proteins or peptides.

1591 In considering allergenicity caused by LMOs, it is important to take into account the exposure to proteins
1592 newly expressed by the LMO, including some variants of these proteins (e.g. structural variants of
1593 proteins having sometimes very few difference(s) in amino acids composition – or no difference in amino
1594 acids composition but carrying slightly different saccharide branches – that may display different
1595 allergenic properties through differences in spatial structure) that may be produced uniquely by the LMO.
1596 As a consequence, some allergenicity studies must be carried out with proteins isolated from the LMO
1597 itself, and not obtained from an alternate (surrogate) source such as a bacterial expression system.

1598 It is also possible that allergens known to exist in the recipient or parental organism(s) are produced in
1599 higher amounts, for example by over-expression of the gene that encodes a protein that is known to be a
1600 common allergen.

1601 **Figure 7 – Assessment of the allergenic potential of foods derived from modern biotechnology**



1614 Source: FAO/WHO (2001).

1615 **Multi-trophic interactions and indirect effects** – “Multi-trophic interactions” involve more than two
1616 trophic levels in a food web. They are an important concept in ecology and occur when a change at one
1617 trophic level indirectly affects trophic levels which are more than one step away. Consideration of tri-
1618 trophic interactions and indirect effects may be relevant to biodiversity protection goals.

1619 **Example 21 – Multi-trophic interactions and indirect effects**

1620 An important feature of non-target effects is that they can involve knock-on food-web effects, such as
1621 effects on predators and parasitoids that are exposed to the transgenic product through their prey or hosts
1622 that feed on the GM crop (known as tritrophic exposure), or more complicated linkages. If the prey or
1623 host are unaffected by the transgenic product themselves, they may expose their predators or parasitoids
1624 over a prolonged period of crop growth, and they may also concentrate the transgenic protein in their
1625 bodies to levels higher than those found in the plant tissues.

1626 *Source: Underwood et al. (2013).*

1627 Observations and experimentation to identify such effects are challenging because of the complexity of
1628 ecological interactions, the difficulty of establishing causality between observed variation and treatment
1629 effects (e.g. the presence of the modified genetic element or its products), and natural variability in
1630 populations over time. Moreover, in a food chain (or food web), effects at the trophic levels may become
1631 observable only at a later stage.

1632 **Resistance development** – The extensive use of herbicides and insect resistant LM crops has the potential
1633 to result in the emergence of resistant weeds and insects. Similar breakdowns have routinely occurred
1634 with conventional crops and pesticides. Several weed species have developed resistance to specific
1635 herbicides which are extensively used in combination with herbicide-resistant LM crops. Insect-resistant
1636 Bt-crops similarly could lead to the emergence of Bt-resistant insects (FAO, 2004).

1637 The extent of the adverse effect and possible consequences of the insurgence of resistant weeds and
1638 insects should be thoroughly considered in a risk assessment. Some regulatory frameworks require that
1639 risk management strategies are identified in order lower the risk of resistance development.

1640 **Elements of a case-by-case risk assessment of LMOs**

1641 The case-by-case approach in risk assessment is based on the premise that risks that may arise from the
1642 release of an LMO depend on three main elements: (i) the LMO itself; (ii) the likely potential receiving
1643 environment; and (iii) the intended use of the LMO in question. In order to identify and assess risks, each
1644 of these elements needs to be characterized in a concerted manner and as appropriate for the specific risk
1645 assessment. Moreover, it is important to note that while these three elements may be sufficient to establish
1646 the boundaries of a risk assessment, potential adverse effects may extend past these elements, for
1647 instance, beyond the likely potential receiving environment and the intended use(s) of the LMO.

1648 The information required for each of these elements in a risk assessment may vary in nature and level of
1649 detail from case to case. The following sections provide examples of information that may be relevant for
1650 the characterization of each element above. These sections include several of the “points to consider” as
1651 indicated in paragraph 9 of Annex III of the Protocol.

1652 A large portion of the information listed here is usually included in the LMO request triggering the risk
1653 assessment. The risk assessors can determine whether or not the information provided is sufficient and

1654 adequate for conducting a scientifically sound risk assessment. If needed, they can obtain additional
1655 information by, for instance, carrying out their own investigation or requesting it from the applicant.

1656 ***Example 22 – The case-by-case approach***

1657 “A risk assessment performed for a particular LMO intended to be introduced to one environment may
1658 not be sufficient when assessing the possible adverse effects that may arise if that LMO is to be released
1659 under different environmental conditions, or into different receiving environments. A risk assessment
1660 performed for a particular use of a particular LMO may not be sufficient when assessing the possible
1661 adverse effects that may arise if that LMO is to be used in different ways. Because of this, it is important
1662 for each case to be addressed separately, taking into account specific information on the LMO concerned,
1663 its intended use, and its potential receiving environment.”

1664 *Source:* IUCN (2003).

1665 ***Living modified organism***

1666 ***Characterization of the recipient organism***

1667 In order to identify whether or not the LMO possesses characteristics that may cause potential adverse
1668 effects (see above), it is first necessary to have information about the non-modified recipient organism (or
1669 parental organisms).

1670 For many LMOs, the biology of the recipient organism will strongly influence the potential interactions
1671 of the LMO in the receiving environment. Information on the recipient organism is therefore essential as
1672 it will help the risk assessor identify the exposure, its scenarios and, ultimately, if any risk is posed by an
1673 LMO.

1674 The information that is needed for the characterization of the recipient organism will vary depending on
1675 each case. For example, the nature and detail of information about the recipient organism that is required
1676 may differ between small-scale releases for experimental purposes and large-scale commercial releases. It
1677 normally includes the biological and reproductive characteristics of the recipient organism that can be
1678 important for determining the potential exposure of other organisms, such as predators, prey, competitors
1679 or pathogens, to the LMO in question in the likely potential receiving environment.

1680 For many species of LMOs, information on the recipient organism can be found in biology documents,
1681 such as those published by the Organization for Economic Co-operation and Development (OECD)²⁸ and
1682 the Canadian Food Inspection Agency (CFIA).²⁹

1683 The LMO will, in most cases, share most of its genetic characteristics with its actual recipient organism
1684 (i.e. the one used in the modification) rather than with other genotypes of the same species. Thus, it is also
1685 important to consider, whenever possible, comparative data from the actual non-modified recipient
1686 organism (see the section on “The choice of comparators”).

1687 Information about recipient organism to be considered may include:

²⁸ See <http://bch.cbd.int/database/record-v4.shtml?documentid=48496>.

²⁹ See <http://www.inspection.gc.ca/english/plaveg/bio/dir/biodoce.shtml>.

1688 *Taxonomic status* – This information is useful for identifying the recipient organism and ensuring that
1689 information provided and cited during the assessment pertains to the organism for which the assessment is
1690 being carried out. Typically, the taxonomic status includes the scientific name (i.e. genus and species, for
1691 example, *Zea mays*) and information about the taxonomic family (e.g. Poaceae). This may also include
1692 other information used to further classify (e.g. sub-species, variety, strain) or differentiate the recipient or
1693 parental organism(s) (e.g. ploidy level or chromosome number).

1694 *Common name* – The familiar or colloquial names for the recipient organism that may be commonly used
1695 in the country of introduction and in international trade may be useful for finding information relevant to
1696 the biology of the organism. Caution is recommended when using information about recipient organism
1697 when only common names (versus the scientific name) are used because the same common name can be
1698 applied to more than one species.

1699 *Biological characteristics* – Information on the biological characteristics of the recipient organism, such
1700 as the production of endogenous toxins and allergens, its reproductive biology, dispersal of seeds and
1701 vegetative propagules, and growth habits, are also important points for consideration.

1702 *Origin* – The origin of the recipient organism refers to its place of collection and may be important
1703 because populations within a species (e.g., variety, strain, isolate, etc.) may have significantly different
1704 characteristics. For domesticated species, this may be supplemented with a pedigree map where available.

1705 *Centres of origin and centres of genetic diversity* – Knowledge of the centre(s) of origin and genetic
1706 diversity can provide information on the presence of sexually compatible species and the likelihood of
1707 ecological interactions in the receiving environment. In the absence of more specific information, the
1708 centre of origin can also offer insight into the biology of the species (e.g. habitats to which the species is
1709 adapted).

1710 *Habitat where the recipient or parental organism(s) may persist or proliferate* – Information about the
1711 ecosystems and habitats (e.g. temperature, humidity, altitude, etc) where the recipient organism is known
1712 to be native and where it may have been introduced and is now established provides useful baseline
1713 information. This allows the risk assessors to understand the range of habitats in which the species exists,
1714 the range of behaviours exhibited in those habitats, and how characteristics of the species determine the
1715 range of habitats where it can persist or proliferate. This information can be very valuable in determining
1716 the likely potential receiving environment and, consequently, the level of exposure to the LMO. Likewise,
1717 the ecological characteristics of the recipient organism will help determine which organisms in the likely
1718 potential receiving environment are likely to come into contact, either directly or indirectly, with the
1719 LMO and will help determine the exposure pathways. For more details on the type of information that
1720 may be useful, see the section “Likely potential receiving environment” below.

1721 The history of use can be very valuable as well. If an organism persists in heavily managed environments
1722 (e.g. agriculture, silviculture or recreationally managed land) then this will provide information about the
1723 conditions necessary for its survival. It may also provide direct indications of how the LMO will behave
1724 in other managed environments.

1725 *Description of the genetic modification*

1726 Information on the genetic material that was introduced or modified, as well as the method used for the
1727 genetic transformation is useful in identifying novel properties of the LMO such as, what new gene
1728 products are expressed and which of the endogenous genes of the recipient or parental organism(s) may
1729 be affected by the genetic modification.

1730 Typically the description of the genetic modification includes information on (i) the “donor organism(s)”
1731 or the source of the inserted genetic element(s); (ii) characteristics of each modified genetic element,
1732 including their intended and known biological function(s); (iii) the vector used, if applicable; and (iv) the
1733 transformation method. Below is a brief explanation on each of these points:

1734 *Donor organism(s)* – The relevant information on the donor organism(s) includes its taxonomic status,
1735 common name, origin and relevant biological characteristics.

1736 *Modified genetic elements* – The relevant information on the modified genetic elements encompasses the
1737 name, sequence, function and other characteristics of all the nucleic acid sequences that were inserted,
1738 deleted or modified in the LMO. These include not only the target gene(s) but also, for example, all
1739 marker genes, regulatory sequences, and any non-coding DNA. If available, a history of use may be
1740 important with regards to potential toxicity or allergenicity of the gene products derived from the donor
1741 organism. If the genetic elements originate from a donor organism that is known to be a pest or pathogen
1742 it is also relevant to know if and how these elements contribute to the pest or pathogenic characteristics.

1743 *Vector* – In molecular biology, a vector is a nucleic acid molecule used as a vehicle to transfer foreign
1744 genetic material into a cell. If a vector, for example a plasmid, was used for the transformation, relevant
1745 information includes its identity, source or origin, and its host range.

1746 *Transformation method* – Specifying the method that was used in the transformation (e.g. *Agrobacterium*
1747 mediated, particle gun, etc.) is also relevant when describing the genetic modification. Depending on the
1748 transformation method, parts of the vector(s) may also be incorporated into the genome of the newly
1749 developed LMO.

1750 *Characteristics of the modification* – This refers to information about whether or not the inserted or
1751 modified genetic elements are present and functioning as expected in the LMO. Normally this involves
1752 confirmation that the DNA insert or modified genetic element is stable in the genome of the LMO.
1753 Information such as the insertion site in the genome of the recipient or parental organism(s), cellular
1754 location of the insert (e.g. chromosomal, extrachromosomal, or chloroplast DNA), its mode of inheritance
1755 and copy number may also be relevant.

1756 *Identification of the LMO*

1757 With regard to the identification of the LMO, the following are important points to consider:

1758 *Unique identifiers* – A Unique identifier is a code provided by the LMO developer to a transformation
1759 event³⁰ derived from recombinant DNA techniques to enable its unequivocal identification. Each unique
1760 identifier is made up of a sequence of 9 alphanumeric digits, for example MON-89788-1, assigned
1761 according to the OECD guidance document (OECD, 2006).

1762 *Detection and identification methods* – The availability of methods for detection and identification of the
1763 LMO may be considered as well as their specificity, sensitivity and reliability. This information may be
1764 relevant not only for assessing risks but also when considering possible monitoring and risk management
1765 strategies (see step 5 below). Some regulatory frameworks require a description of such methods as a
1766 condition for regulatory approval in order to ensure the tools to assist with monitoring and risk
1767 management are available.

³⁰ An LMO with a specific modification that is the result of the use of modern biotechnology according to Article 3 (i) (a) of the Protocol.

1768 The Biosafety Clearing-House of the Cartagena Protocol maintains an LMO registry³¹ containing,
 1769 amongst other things, information on unique identifiers, molecular characteristics and available detection
 1770 methods for the LMOs addressed in countries' decisions.

1771 ***Example 23 – CFIA Detection and identification method criteria***

1772 According to the Canadian Food Inspection Agency, acceptable methods for detection and identification
 1773 of LMOs must address the following:

1774 **Test Type** - Methods must be suitable and may be protein, RNA or DNA based. Phenotypic based
 1775 methods will not generally be considered suitable.

1776 **Limit of detection** - Methods must meet the following sensitivity and accuracy requirement:

1777 • For those methods that are grain based, the method must be able to detect 0.2% modified grain
 1778 (2 grains in 1000) with a 95% confidence interval.

1779 • For those methods that are not grain based (e.g. single ingredient feed) the method must be able
 1780 to detect 0.2% modified material in a sample with a 95% confidence interval.

1781 **Procedural clarity** -The method must be complete and laid out in a step wise fashion that may be easily
 1782 followed by a person unfamiliar with the method. Detailed descriptions of sample size, replicates,
 1783 extraction procedure, expected results (figures/sequences), interpretation and acceptance criteria must be
 1784 included.

1785 **Cross reactivity** - The method must be shown to be specific to the PNT of interest. Any potential for
 1786 cross reactivity must be clearly stated. Cross reactivity data must be provided demonstrating that the
 1787 method does not cross-react with other commercially available PNTs of the same species with similar
 1788 traits/modifications that are currently available in the Canadian marketplace.

1789 **Reference material** - The company must provide appropriate reference materials to the CFIA upon
 1790 request. Appropriate reference material will be determined by the CFIA based on the method provided.

1791 **Contact information** - The company must provide contact information for a technical support person.

1792 *Source: CFIA (website).*

1793 ***Likely potential receiving environment(s)***

1794 The Protocol calls for the characterisation of the “likely potential receiving environment” of an LMO.
 1795 According to UNEP (1995), the “potential receiving environment” is the range of environments
 1796 (ecosystem or habitat, including other organisms) which are likely to come in contact with a released
 1797 organism due to the conditions of the release or the specific ecological behaviour of the organism. In
 1798 other words, the likely potential receiving environment of an LMO encompasses both the environments
 1799 where the LMO will be intentionally introduced as well as other environments which are likely to be
 1800 exposed to the LMO.

31 <http://bch.cbd.int/database/organisms/>.

1801 As such, during a risk assessment, in addition to the area where the LMO will be intentionally introduced,
1802 the relevant characteristics of the likely potential receiving environment of an LMO should also be
1803 thoroughly examined with particular attention given to areas where exposure levels to the LMO will be
1804 the highest.

1805 The characterization of the likely potential receiving environment takes into account its ecological
1806 characteristics, including physical location/geography, climate, its biological entities and their
1807 interactions. The characterization of the likely potential receiving environment will help in selecting
1808 appropriate assessment endpoints for the risk assessment (see Module 2) and will also affect the
1809 assessment of the potential interactions of the LMO with other organisms.

1810 To determine the likely potential receiving environment, risk assessors may consider potential pathways
1811 for dispersal of the LMO as well as the habitats where the recipient/parent organism(s) may persist or
1812 proliferate.

1813 An analysis of possible dispersal routes and mechanisms is important when establishing the likely
1814 potential receiving environments. Different dispersal mechanisms may exist and could be inherent either
1815 to the LMO (e.g. altered seed characteristics), its intended use (e.g. shipment practices) or the receiving
1816 environment (e.g. proximity to a river). A scientifically sound risk assessment takes into consideration all
1817 possible dispersal mechanisms, keeping in mind the biology of the LMO and non-modified recipient or
1818 parental organism(s), in a concerted manner for each case.

1819 Information about the likely potential receiving environment can include considerations on both large
1820 scale (e.g. climate) and small scale characteristics (e.g. microclimate) depending on the complexity of the
1821 environment. The type of information on the likely potential receiving environment and the level of detail
1822 depend on the nature of the LMO and its intended use, in accordance with the case-by-case principle.

1823 It may not be possible or practical to consider every possible interaction between the LMO and the
1824 receiving environment. Such challenges and limitations should be acknowledged during the risk
1825 assessment process.

1826 Below are descriptions of some physical and biological characteristics of the likely potential receiving
1827 environment(s) that can be considered in the risk assessment of LMOs. This is an indicative list thus the
1828 information required to satisfy the needs of the assessment will vary depending on the nature of the LMO
1829 and its intended use.

1830 The physical or “abiotic” characteristics of the likely potential receiving environment may have a great
1831 impact on the ability of an LMO to survive and persist.

1832 *Geography and climate* – Geography encompasses characteristics such as latitude, which will influence
1833 day-length, and altitude. Climate encompasses temperature, precipitation, humidity, wind and other
1834 meteorological measures over long periods of time. For the purposes of environmental risk assessment,
1835 geography and climate are among the most important factors impacting the ability of an LMO to survive
1836 and persist. For LM plants, temperature and precipitation are likely to be key determinants. Seasonality
1837 (variations in climate on an annual cycle) can also be an important consideration in the potential survival
1838 and persistence of an LMO.

1839 *Soil* – The type and quality of soil can greatly influence the ability of an LM plant to survive or persist
1840 without land management. The type and quality of a soil are heavily influenced by the organisms living in

1841 its proximity, but abiotic factors such as climate, geography and topography will also all play a role in
1842 determining its characteristics (e.g. mineral content, moisture level, texture etc.).

1843 *Management status* – The management status of an environment is a measure of how much human
1844 intervention takes place in order to maintain a particular condition. A separate but related concept is
1845 “disturbance” which can be considered the amount of human activity that affects the environment but
1846 without the intention of maintaining a particular condition. Management and disturbance may greatly
1847 influence the ability of an LMO to survive and persist in the environment. Likely potential receiving
1848 environments can range from highly managed to unmanaged and from highly disturbed to undisturbed.

1849 The biological characteristics of the likely potential receiving environment consist of all the living
1850 organisms present in the environment, its biological communities and the interactions among them.

1851 Both managed and unmanaged environments contain complex biological characteristics that pose
1852 challenges for environmental risk assessments.

1853 As with any other organism, an LMO released into the environment is expected to have many interactions
1854 with other organisms. For the purposes of environmental risk assessment, it is critical to develop
1855 verifiable risk scenarios and identify the appropriate species that may be impacted by the presence of the
1856 LMO in the environment. For example, gene flow and possibly introgression may occur when sexually
1857 compatible species are present in the likely potential receiving environment. The selection of suitable
1858 representative species in the likely potential receiving environment is also informative (see section on
1859 “Selecting relevant assessment endpoints or representative species”).

1860 *Intended use*

1861 The characteristics of the intended use of an LMO and management practices associated with it, such as
1862 tilling and the use of pesticides, can provide valuable information and context for the risk assessment
1863 process. Understanding the intended use also helps a risk assessor to perform an exposure assessment
1864 starting with the environment where the LMO will be deliberately introduced followed by considering
1865 whether or not the LMO is likely to disseminate or persist outside of this environment.

1866 To illustrate how the intended use can affect the likelihood of a risk posed by an LMO, a hypothetical
1867 case of an LM tree being used for wood production could be considered, in which the first flowering
1868 would occur after 15 years of planting, but logging would take place after only 10 years. As such, the
1869 intended use would result in the LM tree being logged before its first flowering. Consequently, in this
1870 hypothetical case, the intended use would influence the likelihood of potential outcrossing³² of this LM
1871 tree.

1872 Information regarding the intended use of the LMO may also take into account any new or changed use in
1873 comparison to the recipient or parental organism(s), for example, in cases where the recipient or parental
1874 organism(s) is a crop for human consumption but the intended use of the LMO is the production of a
1875 compound for pharmaceutical or industrial use.

1876 The scale and type of the introduction into the environment, for example, field trials versus commercial
1877 releases, and whether or not any risk management strategy is being proposed, may also be relevant when

³² “Outcrossing” refers to the transmission of genetic elements from one group of individuals (e.g., population, crop variety) to another. In plants, outcrossing most commonly results from cross-pollination.

1878 considering the intended use. Many regulatory frameworks, for instance, require that submissions for field
1879 trials be accompanied by information on risk management strategies to reduce exposure to the LMO.

1880 Considerations on the intended use may also take into account national and regional experiences with
1881 similar organisms, their management and exposure to the environment.

1882 ***Step 2: Evaluation of the likelihood***

1883 This step entails an evaluation of the likelihood, i.e. probability, of the adverse effect occurring, taking
1884 into account the level and kind of exposure of the likely potential receiving environment to the LMO.

1885 After the potential adverse effects of the LMO have been identified, the risk assessment proceeds to a
1886 formal analysis of the likelihood and consequence of these effects with respect to the identified
1887 assessment endpoints.

1888 Although the steps of evaluating likelihood and consequences are dealt with separately in Annex III of the
1889 Protocol, some risk assessment approaches consider these steps simultaneously or in reverse order.

1890 The likelihood of an adverse effect is dependent upon the probability of one or a series of circumstances
1891 actually occurring.

1892 It is difficult to describe in detail an evaluation of likelihood or consequence without using an example
1893 because the evaluation is dependent on the nature of the LMO, the receiving environment and, if
1894 appropriate, on the risk scenario used. The following are two examples:

- 1895 • In a case where outcrossing of the transgene with a non-modified organism is determined to be
1896 possible (i.e. the two species are sexually compatible), the risk assessment may consider both the
1897 likelihood of the outcrossing and, if relevant, the likelihood of the LMO progeny to persist or
1898 proliferate. Considerations on the latter may be based, for example, on assessing whether or not the
1899 transgene would affect the fitness level of the progeny (i.e. the capability of individuals to compete
1900 and reproduce in a given environment). If the transgene induces a positive fitness effect, the likelihood
1901 that the population resulting from the outcrossing would increase is high. On the other hand,
1902 transgenes that have a negative fitness effect would result in a low likelihood that the resulting
1903 population would increase. Transgenes that have a neutral impact on fitness may persist in populations
1904 at low levels depending on the rate of outcrossing or introgression as well as the overall population
1905 dynamics of the species.
- 1906 • In a case where the risk scenario involves the potential toxicity of an LM plant (or a substance
1907 produced by an LM plant) to a herbivorous insect: the analysis of likelihood may consider the
1908 probability that the insect will be present, that the insect will feed on the LMO and that the insect will
1909 ingest a sufficient quantity of the LMO to suffer an adverse effect. Likelihood may consider
1910 probabilities on an individual level (e.g. what are the chances an individual insect may consume the
1911 LM plant) or on a population level (e.g. what percentage of the population of insects will come into
1912 contact with the LMO) or both.

1913

1914 ***Example 24 – Likelihood of introgression***

1915 “To evaluate a possible ecological effect of an inserted gene being introgressed into a natural population it
 1916 is important to estimate the probability of introgression. Such a probability estimate can be obtained from
 1917 measurements of hybridisation rates, assumed selective advantage of inserted gene, and fitness
 1918 measurements of parent plants, hybrid plants, and plants from the first and second back-cross generations.

1919 If hybrids are formed and it is likely that these hybrids are able to survive the consequences should be
 1920 discussed.”

1921 *Source:* Ministry of Environment and Energy Denmark (1999).

1922 ***Step 3: Evaluation of the consequences***

1923 The consequence of an adverse effect is the outcome, extent and severity of an adverse effect associated
 1924 with exposure to an LMO, its handling and use, or its products (in the context of Annex III paragraph 5).
 1925 Should adverse effects occur, they may be severe, minimal, or anywhere in between. The evaluation of
 1926 the consequences may consider the effects on individuals (e.g. mortality, reduced or enhanced fitness,
 1927 etc.) or on populations (e.g. increase or decrease in number, change in demographics, etc.) depending on
 1928 the adverse effect under evaluation.

1929 The risk assessment should consider the consequences of each adverse effect based on a concerted
 1930 analysis of what is known about the LMO, the likely potential receiving environment and the assessment
 1931 endpoints, as well as the likelihood assessment.

1932 ***Example 25 – Consequences of effects to non-target organisms***

1933 When the inserted trait cause the plant to produce potentially toxic compounds, or if flower characteristics
 1934 are changed, i.e. colour, flowering period, pollen production etc. then effects on pollinators has to be
 1935 measured. A test of effects on honeybees (*Apis melliferae*) is obligatory because of the importance of
 1936 honeybees as pollinators of both wild and crop species and because standardised test protocols testing for
 1937 effects of conventional pesticides exists for this pollinator. These tests include exposure through nectar
 1938 and pollen.

1939 *Source:* Ministry of Environment and Energy Denmark (1999).

1940 Also using an example where gene flow and introgression could lead to a potential adverse effect, what
 1941 impact the presence of a transgene will have on biodiversity will depend on its effect on individual fitness
 1942 as well as on the importance of that species relative to the protection goals. For instance, if a sexually
 1943 compatible species, present in the receiving environment, is directly relevant to a biodiversity protection
 1944 goal (e.g. it is a protected species) then the impact on biodiversity can be assessed by looking directly at
 1945 the impact of the transgene on the population. If the sexually compatible species is not directly related to
 1946 a biodiversity management goal, then the impact of the expression of the transgene will be dependent on
 1947 indirect interactions. Indirect effects may be challenging to assess (see step 1), and are dependent on the
 1948 ecological importance of the species.

1949 **Step 4: Estimation of the overall risk**

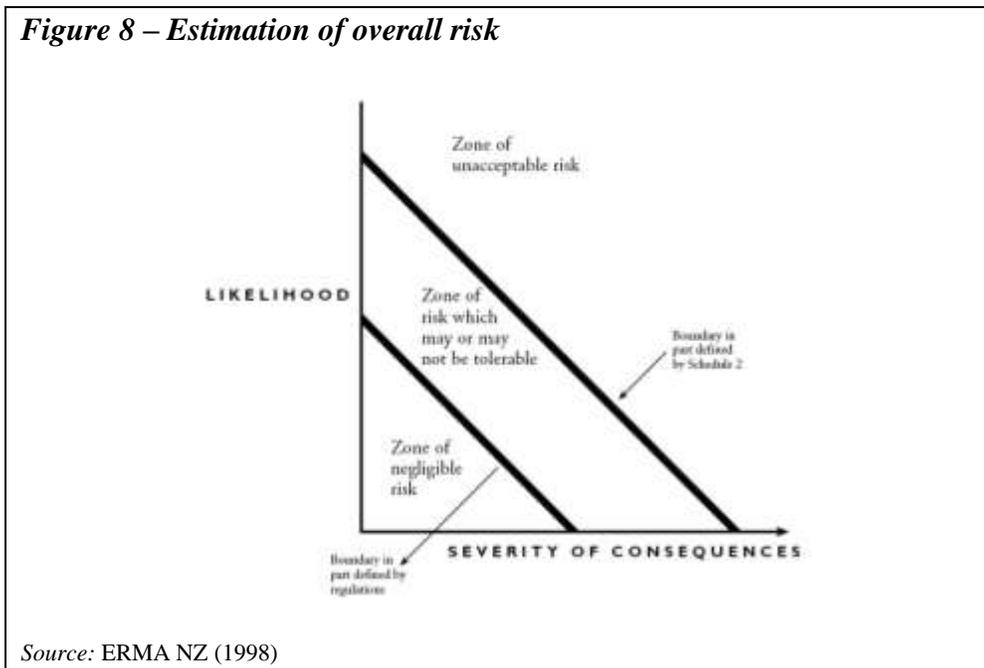
1950 This step consists of the integration of the likelihood and consequence of each of the individual risks
1951 identified through the preceding steps and takes into account any relevant uncertainty that emerged thus
1952 far during the process. In some risk assessment approaches, this step is referred to as “risk
1953 characterization”.

1954 To date, there is no universally accepted method to estimate the overall risk but a variety of guidance
1955 materials are available that address this topic (see for instance, documents under “Scientific and technical
1956 issues / risk assessment” in the Biosafety Information Resource Centre, BIRC).³³

1957 In rare instances, the risk characterization results in a quantitative value (e.g. 6% of a population will be
1958 exposed to a stressor, and of that percentage half will experience mortality). More frequently, the risk
1959 characterization for an LMO will be qualitative. In such cases, description of the risk characterization
1960 may be expressed as, for instance, ‘high’, ‘medium’, ‘low’, ‘negligible’ or ‘indeterminate due to
1961 uncertainty or lack of knowledge’.

1962 The outcome of this step is the assessment of the overall risk of the LMO. Once this is achieved, it is
1963 helpful to determine, as an internal quality control, whether the risk assessment has met the criteria
1964 established at the beginning of the process taking into account also those criteria established in the
1965 relevant policies in practice with regard to the protection goals, assessment endpoints and risk thresholds
1966 (i.e. the level of tolerance to a certain risk or the level of change in a particular variable beyond which a
1967 risk is considered unacceptable).

1968 **Figure 8 – Estimation of overall risk**



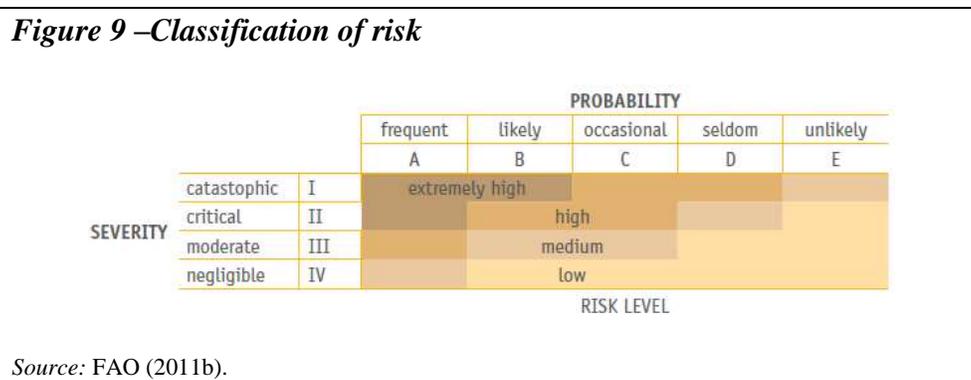
1969

1970

1971

³³ <http://bch.cbd.int/database/resources>.

1972



1973

1974

1975 **Step 5: Acceptability of risk and identification of risk management and**
1976 **monitoring strategies**

1977 Annex III of the Protocol states that the risk assessment methodology may entail “a recommendation as to
1978 whether or not the risks are acceptable or manageable, including, where necessary, identification of
1979 strategies to manage these risks” and “where there is uncertainty regarding the level of risk, it may be
1980 addressed by requesting further information on the specific issues of concern or by implementing
1981 appropriate risk management strategies and/or monitoring the living modified organism in the receiving
1982 environment”³⁴.

1983 For the “acceptability” of risks, please refer to the section “Recommendations as to whether or not the
1984 risks are acceptable or manageable” below.

1985 **Risk management**

1986 Risk management strategies refer to measures to ensure that risks identified in the risk assessment are
1987 reduced or controlled which may be implemented after the LMO is introduced into the environment (or
1988 placed in the market, if applicable). Risk management strategies can be useful to increase confidence
1989 when dealing with uncertainty or, in the case where risks have been identified, to reduce the likelihood or
1990 impact of the potential adverse effect.

1991 **Example 26 – Application of management strategies for risks from the deliberate release or**
1992 **marketing of LMO(s)**

1993 “The risk assessment may identify risks that require management and how best to manage them, and a
1994 risk management strategy should be defined.”

1995 *Source: The European Parliament and the Council of the European Union (2001).*

1996 Risk management strategies may aim to reduce the likelihood or consequences of potential adverse effects
1997 and are referred to as “preventive measures” and “mitigation measures”, respectively. Some approaches
1998 to risk assessment may also include the identification of measures to control an adverse effect should it
1999 occur.

³⁴ Paragraphs 8(e) and (f) of Annex III.

2000 For LMOs, common risk management strategies have typically been designed to reduce the likelihood of
2001 exposure, but depending on the specific case, management options might include a variety of measures
2002 that are directly or indirectly related to the LMO. Some examples of risk management strategies for
2003 LMOs include: minimum distances from sexually compatible species if there is evidence that gene flow
2004 could cause adverse effects, destruction of seeds remaining in the field or of volunteers after harvest,
2005 restrictions from introduction into specified receiving environments, etc.

2006 Certain risk assessment steps, particularly the evaluation of likelihood and consequences may need to be
2007 re-evaluated to take into account each of the identified risk management strategies since these may affect
2008 the estimation of the overall risks.

2009 **Monitoring**

2010 A risk assessor may identify the need for a strategy to monitor the receiving environment for adverse
2011 effects that may arise after the introduction of the LMO and include it as part of the recommendations for
2012 the Competent National Authority(ies). This may happen, for instance, when the level of uncertainty
2013 could affect the overall conclusions of the risk assessment. Moreover, some biosafety frameworks may
2014 have a policy to request a plan for monitoring as part of the risk assessment of all or particular types of
2015 LMOs.

2016 Monitoring after the release of the LMO aims at detecting changes (e.g. in the receiving environment(s)
2017 or in the LMO) that could lead to adverse effects.

2018 ***Example 27 – Post-market monitoring***

2019 “Post-market monitoring may be an appropriate risk management measure in specific circumstances.
2020 Following the safety assessment, the need and utility for post-market monitoring should be considered, on
2021 a case-by-case basis, during risk assessment and its practicability should be considered during risk
2022 management.”

2023 *Source: Health Canada (2006).*

2024 Monitoring strategies may be designed on the basis of the protection goals identified by national
2025 legislation and regulation, if available, and parameters that are relevant to the indication of any increasing
2026 risk to the assessment endpoints in a “top-down” approach, or on the basis of specific risks in a “bottom-
2027 up” approach.

2028 The strategies may include “general surveillance” that can make use of existing, broader monitoring
2029 programs that may identify unexpected effects of the LMOs or traits, such as long-term effects; or be
2030 “case-specific” where potential adverse effects identified during the risk assessment are investigated.
2031 Monitoring for the development of resistance in insect pests following introduction of pesticide producing
2032 LM crops would be an example of a “case-specific” scenario. Monitoring for the abundance of beneficial
2033 insect species in an environment would be an example of “general surveillance”.

2034

2035 ***Example 28 – Case-specific monitoring and general surveillance of LM plants***

2036 “The environmental monitoring of the GM plant will have two focuses: (1) the possible effects of the GM
 2037 plant, identified in the formal risk assessment procedure, and (2) to identify the occurrence of adverse
 2038 unanticipated effects of the GM plant or its use which were not anticipated in the environmental risk
 2039 assessment. [...] Appropriate case-specific monitoring measures should be developed on a case-by-case
 2040 approach depending upon the outcomes of the risk assessment. Possible risks identified in the
 2041 environmental risk assessment should be studied in hypothesis-driven experiments and tests.

2042 The objective of general surveillance is to identify the occurrence of unanticipated adverse effects of GM
 2043 plants or their use on human health or the environment that were not anticipated in the environmental risk
 2044 assessment. Since no specific risk is identified, no hypothesis of risk can be tested, so it is difficult to
 2045 propose specific methods to carry out general surveillance.”

2046 *Source: EFSA (2006).*

2047 Where it is appropriate, other potential adverse effects such as delayed, cumulative, combinatorial³⁵ or
 2048 indirect effects resulting from the LMO, the trait or the inserted or modified genes may be considered in
 2049 the post-release monitoring strategies.

2050 The level of specificity of the monitoring strategies may vary depending on the LMO(s), the intended
 2051 use(s) and/or the likely potential receiving environment(s). Therefore, it is essential that a detailed
 2052 methodology for each identified strategy also be identified. The methodology may include, for example,
 2053 the frequency, locations and methods of sampling, as well as methods of analysis (e.g. laboratory testing).

2054 **Preparing a risk assessment report and recommendation**

2055 The outcomes of a risk assessment are often presented in the form of a written report prepared by the risk
 2056 assessor(s). The report is primarily intended to assist the decision makers in making informed decisions
 2057 regarding the safe use of an LMO.

2058 Presenting the results of a risk assessment could be categorized as a form of risk communication. As in
 2059 any form of communication, risk assessors should be mindful of the intended recipients, which in addition
 2060 to decision makers may also include regulators, risk managers, other risk assessors and the general public
 2061 amongst others.

2062

35 “Cumulative effects” are effects due to the presence of multiple LMOs or their products in the receiving environment. “Combinatorial affects” are effects that arise from the interactions between two (or more) genes in one organism, including epistatic interactions.

2063 ***Example 29 – Risk communication***

2064 Risk communication is the interactive exchange of information and opinions among assessors, risk
2065 managers, consumers, industry, the academic community and other interested parties throughout the risk
2066 analysis process. The information exchange concerns risk related factors and risk perceptions, including
2067 the explanation of risk assessment findings and the basis of risk management decisions. It is vitally
2068 important that risk communication with the public comes from credible and trusted sources.

2069 *Source: FAO (2001).*

2070 It is important that the report is presented in a well-structured form, which not only facilitates the
2071 deliberations of decision makers, but also allows for an easier exchange of information and experience.
2072 The context and scope of the risk assessment should be clearly explained as other institutions (e.g. in the
2073 same or in different countries) may have an interest in understanding how the risk of a particular LMO
2074 was assessed.

2075 With regard to the sharing of information, a Party to the Protocol is required to submit to the Biosafety-
2076 Clearing House (BCH) all “summaries of its risk assessments or environmental reviews of living
2077 modified organisms generated by its regulatory process, and carried out in accordance with Article 15,
2078 including, where appropriate, relevant information regarding products thereof, namely, processed
2079 materials that are of living modified organism origin, containing detectable novel combinations of
2080 replicable genetic material obtained through the use of modern biotechnology” (Article 20). This will
2081 include all risk assessments generated to support decisions regarding LMOs for intentional introduction
2082 into the environment (Articles 8, 10 and 13) or for direct use as food or feed, or for processing (Article
2083 11) whether they are triggered by a transboundary movement or by an internal request.

2084 The required contents and format of a risk assessment report are generally defined by the Competent
2085 National Authority(ies) that have the responsibility to make decisions on the LMO(s) in the context of the
2086 national biosafety framework.

2087 A risk assessment report typically comprises of an analytic synthesis of all the relevant steps and results
2088 of the risk assessment process, including an overview of the context and scope of the risk assessment,
2089 methodology used and a detailed summary of the results of the overall risk estimation, including the
2090 identification of individual risks, as well as the likelihood and consequences of the potential adverse
2091 effects.

2092 The report may also contain an evaluation of the availability and quality of the scientific and technical
2093 information that was deemed necessary to perform the assessment and characterize the risks, and whether
2094 or not there were gaps in the information.

2095 An analysis of all identifiable uncertainties and how they may impact the overall conclusions of the
2096 assessment is also a critical element of the report. This includes uncertainties identified at each step of the
2097 risk assessment process as well as those remaining at the end of the risk assessment.

2098 Finally, the risk assessment report often contains a set of recommendations regarding the acceptability
2099 and manageability of the risks posed by the LMO and the identification of appropriate risk management
2100 and monitoring strategies.

2101 The information above can be organized under five broad topics depending on the requirements of the
2102 National Authority that is responsible for the risk assessment:

- 2103 (a) Background, context and scope of the risk assessment;
- 2104 (b) Characterization and estimation of risks;
- 2105 (c) Description of risk management and monitoring strategies identified during the risk assessment;
- 2106 (d) Consideration of remaining uncertainty; and
- 2107 (e) Recommendations as to whether or not the risks are acceptable or manageable.

2108 An overview of the information which may be included under each of these topics may be found in the
2109 following sections.

2110 ***Background, context and scope of the risk assessment***

2111 This part of the report focuses on describing the issues that were considered while setting the context and
2112 scope of the risk assessment. Basically, this section of the report sets the scene for the reader to follow a
2113 clear progression through the subsequent sections of the report.

2114 A risk assessment report usually specifies the mandate that was given to the risk assessor(s) and includes
2115 a description of the procedure that was followed in conducting the risk assessment, an indication of which
2116 institution has carried out the risk assessment, and which, if any, other institutions were consulted or were
2117 part of the process. Any other information that helps in understanding the context in which the risk
2118 assessment was carried out is also typically included in this part of the report.

2119 Previous approvals or prohibitions of the same LMO, if any, including the regulatory status of the LMO
2120 in the country of export or import as well as in any other country may also be included in this section, if
2121 appropriate.

2122 The report describes how the requirements of the national regulatory framework were taken into account
2123 including which protection goals were identified as relevant in the context of the risk assessment and how
2124 assessment endpoints were selected.

2125 In summary, the following information may be included in this section of the report:

- 2126 (a) Contact details of the LMO developer;
- 2127 (b) Type of approval sought (e.g. introduction into the environment);
- 2128 (c) Contact details of the institution responsible for the risk assessment;
- 2129 (d) Relevant regulation;
- 2130 (e) Relevant protection goals and assessment endpoints;
- 2131 (f) Previous approvals or prohibitions of the same LMO;
- 2132 (g) Overview of the terms of reference for the risk assessment; and
- 2133 (h) Consulted experts or panel of experts, if applicable, and how the involved experts were chosen
2134 and how possible conflict of interests were identified and was managed.

2135 In some cases, the bulk of information presented in this section of the report may be extracted from the
2136 request triggering the risk assessment, the national regulatory framework, including environmental and
2137 biosafety policies or guidelines, and national biosafety-related databases.

2138

2139 ***Characterization and estimation of risks***

2140 This section of the report focuses on the outcomes of the risk assessment steps in accordance with the
2141 steps in Annex III of the Protocol and as described above.

2142 Depending on the specific mandate and scope of the risk assessment, the following information may be
2143 included in this section of the report:

- 2144 (a) Description of the LMO (e.g. recipient or parental organism(s), transformation method, inserted
2145 or modified sequences, novel traits, purpose of the genetic modification), its intended use and
2146 the likely potential receiving environment(s), including considerations on how the baselines
2147 were established and appropriate comparator(s) chosen;
- 2148 (b) Considerations of the availability and quality of information used during the risk assessment;
- 2149 (c) Methodology used in the risk assessment, explaining, if necessary, the use of terms;
- 2150 (d) Description of the potential adverse effects and risk scenarios arising from the novel
2151 characteristics of the LMO;
- 2152 (e) Analyses of the likelihood and consequences of each identified potential adverse effect; and
- 2153 (f) Estimation of the overall risk posed by the LMO.

2154 The information relevant to each of the items above may vary in nature and level of detail on case-by-case
2155 basis, depending on the LMO concerned, its intended use and the likely potential receiving environment.

2156 While information related to the description of the LMO and its intended use may be obtained in part
2157 from the LMO application, the bulk of information to be presented in this section of the report is obtained
2158 through the risk assessment process for the specific case at hand.

2159 ***Description of risk management and monitoring strategies***

2160 If risk management and monitoring strategies were identified during the risk assessment process (see step
2161 5), the risk assessment report should contain a section detailing any strategies to minimize the risks
2162 identified.

2163 The risk assessment report may include, for instance:

- 2164 (a) How each identified strategy is expected to contribute to minimizing the likelihood or
2165 consequence of potential adverse effects (e.g. by reducing the exposure to the LMO or the
2166 consequences of the potential harm);
- 2167 (b) Details of the methodology for each identified risk management or monitoring strategy
2168 including, for instance, the frequency, locations and methods of sampling, as well as methods
2169 of analysis, including laboratory testing when appropriate;
- 2170 (c) Any uncertainty regarding the effectiveness of any such management or monitoring strategy;
- 2171 (d) An indication as to whether and how different management strategies can be combined to
2172 further minimize uncertainty or identified risks; and
- 2173 (e) Considerations on unintentional introduction into the environment and emergency measures as
2174 appropriate (see Article 17).

2175 ***Consideration of remaining uncertainty***

2176 As seen in the section on “Overarching issues”, uncertainty is an inherent component of any risk
 2177 assessment, and should be considered in a systematic manner at each step of the risk assessment process.
 2178 Nevertheless, at the end of the risk assessment, uncertainties may still remain with regard to one or more
 2179 specific steps in the process or about the likelihood or consequences of the potential adverse effects.

2180 Annex III of the Protocol addresses this matter by requiring that “Where there is uncertainty regarding the
 2181 level of risk, it may be addressed by requesting further information on the specific issues of concern or by
 2182 implementing appropriate risk management strategies and/or monitoring the living modified organism in
 2183 the receiving environment”.³⁶

2184 Considerations of remaining uncertainties should be included in the risk assessment report. These
 2185 considerations may include:

- 2186 (a) Identification of major information gaps and, where appropriate, indication of whether gathering
 2187 additional data (either before the release or after it by monitoring) would significantly increase
 2188 the overall confidence in the results of the risk assessment;
- 2189 (b) An analysis of uncertainty, including its types (e.g. gaps in the available information, limitations
 2190 of the assessment methodology);
- 2191 (c) Discussion on the level of scientific support to issues where there is uncertainty, including an
 2192 analysis of different scientific views;
- 2193 (d) Discussion of any assumption used in assessing the risks, including its strengths and weaknesses;
- 2194 (e) Discussion of the potential for uncertainties to impact on the overall conclusions of the risk
 2195 assessment; and
- 2196 (f) Identification of any threats of serious or irreversible damage to the environment (basis for the
 2197 adoption of the precautionary approach).

2198 ***Example 30 – Uncertainty and an approach based on the precautionary principle***

2199 “The implementation of an approach based on the precautionary principle should start with a scientific
 2200 evaluation, as complete as possible, and where possible, identifying at each stage the degree of scientific
 2201 uncertainty. Decision-makers need to be aware of the degree of uncertainty attached to the results of the
 2202 evaluation of the available scientific information. Judging what is an “acceptable” level of risk for society
 2203 is an eminently *political* responsibility. [...] Where possible, a report should be made which indicates the
 2204 assessment of the existing knowledge and the available information, providing the views of the scientists
 2205 on the reliability of the assessment as well as on the remaining uncertainties. If necessary, it should also
 2206 contain the identification of topics for further scientific research.”

2207 *Source:* Commission for the European Communities (2000).

2208 ***Recommendations as to whether or not the risks are acceptable or manageable***

2209 Recommendations are one of the most important sections of a risk assessment report as they take into
 2210 account the outcomes of the risk assessment to provide direct science-based advice to the intended

³⁶ Paragraph 8(f) of Annex III.

2211 recipients of the report. A recommendation as to whether or not the risks are acceptable or manageable
2212 should be kept within the scope of the risk assessment and based on its findings.

2213 It is important to note that risk assessor(s) are requested to recommend whether the risks are “acceptable”
2214 or not. However, the definition of "acceptability" may not be part of a risk assessment but could be pre-
2215 established, for example, in thresholds included in government policies or in the mandate given to the risk
2216 assessor. Likewise, the final decision on whether to approve (with or without conditions) or prohibit the
2217 specific use of the LMO is taken during the decision-making process, which may take into account,
2218 depending of the national regulatory framework and among other things, government policies, public
2219 opinion, anticipated benefits, costs of the risk management measures and socio-economic considerations.

2220 In addition to the issues mentioned above, the recommendations section of the report may also include
2221 any relevant information to be considered by the decision makers prior to making a decision. Some issues
2222 that may be relevant include:

- 2223 (a) A recommendation as to whether or not one or more risk management or monitoring strategies
- 2224 should be implemented and, if so, the specific conditions for each such strategy;
- 2225 (b) Considerations of remaining uncertainties; and
- 2226 (c) A recommendation as to if and when the risk assessment should be re-visited.

2227 **References**

2228 Abrahamson WG (website) The *Solidago Eurosta* Gall Homepage – A Resource for Teaching and
2229 Research. Ecology and Evolution. Available at
2230 <http://www.facstaff.bucknell.edu/abrahmsn/solidago/gallresearch.html> (access June 2010).

2231 CFIA (website) Detection and Identification Method Criteria. Canadian Food Inspection Agency (CFIA).
2232 Available at <http://www.inspection.gc.ca/english/plaveg/bio/detecte.shtml> (access May 2010).

2233 Commission for the European Communities (2000) Communication from the Commission on the
2234 precautionary principle. Commission of the European Communities, Brussels, 29 pp. Available at
2235 http://ec.europa.eu/dgs/health_consumer/library/pub/pub07_en.pdf (access May 2010).

2236 EEA (1998) Environmental Risk Assessment - Approaches, Experiences and Information Sources.
2237 Environmental issue report No 4, European Environmental Agency (EEA). Available at
2238 <http://www.eea.europa.eu/publications/GH-07-97-595-EN-C2/riskindex.html> (access July 2010).

2239 EFSA (2006) Opinion of the Scientific Panel on Genetically Modified Organisms on the Post Market
2240 Environmental Monitoring (PMEM) of genetically modified plants (Question No EFSA-Q-2004-061).
2241 European Food Safety Authority (EFSA). Available at
2242 http://www.efsa.europa.eu/en/efsajournal/doc/gmo_op_ej319_pmем_en,0.pdf (access June 2010).

2243 EFSA (2011) Guidance document on Selection of Comparators for the Risk Assessment of GM Plants.
2244 EFSA Panel on Genetically Modified Organisms (GMO), EFSA Journal 9(5): 2149
2245 doi:10.2903/j.efsa.2011.2149. Available at www.efsa.europa.eu/efsajournal.htm (access December 2013).

2246 ERMA NZ (1998) Annotated methodology for the consideration of applications for hazardous substances
2247 and new organisms under the HSNO Act 1996. Environmental Risk Management Authority of New

- 2248 Zealand (ERMA NZ), 30 pp. Available at
2249 http://www.ctfa.org.nz/documents/members/cosmeticlaw/hsno/guides/Annotated_Methodology.pdf
2250 (access September 2013).
- 2251 FAO (2001) Genetically modified organisms, consumers, food safety and the environment. Food and
2252 Agriculture Organization (FAO), Rome, 35 pp. Available at [http://bch.cbd.int/database/record-](http://bch.cbd.int/database/record-v4.shtml?documentid=41952)
2253 [v4.shtml?documentid=41952](http://bch.cbd.int/database/record-v4.shtml?documentid=41952) (access May 2010).
- 2254 FAO (2004) The State of Food and Agriculture: 2003-2004. Part I: Agricultural biotechnology: meeting
2255 the needs of the poor? Section B: The evidence so far. Food and Agriculture Organization of the United
2256 Nations. Available at <http://www.fao.org/docrep/006/Y5160E/y5160e00.htm> (access May 2010).
- 2257 FAO (2011a) Procedures for post-border weed risk management. Second Edition. Plant Production and
2258 Protection Division, Food and Agriculture Organization of the United Nations, Rome, 2011. Available at
2259 [http://www.fao.org/fileadmin/templates/agphome/documents/Biodiversity-](http://www.fao.org/fileadmin/templates/agphome/documents/Biodiversity-pollination/Weeds/Docs/ProceduresPostBorderWeedRiskManagement.pdf)
2260 [pollination/Weeds/Docs/ProceduresPostBorderWeedRiskManagement.pdf](http://www.fao.org/fileadmin/templates/agphome/documents/Biodiversity-pollination/Weeds/Docs/ProceduresPostBorderWeedRiskManagement.pdf) (accessed December 2013).
- 2261 FAO (2011b) Biosafety Resource Book. Food and Agriculture Organization of the United Nations (FAO),
2262 Module C, 90pp. Available at <http://bch.cbd.int/database/record-v4.shtml?documentid=102000> (access
2263 September 2011).
- 2264 FAO/WHO (2001) Evaluation of Allergenicity of Genetically Modified Foods. Food and Agriculture
2265 Organization of the United Nations (FAO) and World Health Organization (WHO), 29 pages. Available
2266 at <http://bch.cbd.int/database/record-v4.shtml?documentid=41976> (access June 2010).
- 2267 GMAC Singapore (website) Genetically Modified Organisms. Genetic Modification Advisory Committee
2268 (GMAC) Singapore. Available at
2269 http://www.gmac.gov.sg/Index_FAQs_Genetically_Modified_Organisms.html (access October 2013).
- 2270 Health Canada (2006) Guidelines for the Safety Assessment of Novel Foods. Food Directorate Health
2271 Products and Food Branch, Health Canada, June, 2006. Available at [http://bch.cbd.int/database/record-](http://bch.cbd.int/database/record-v4.shtml?documentid=101221)
2272 [v4.shtml?documentid=101221](http://bch.cbd.int/database/record-v4.shtml?documentid=101221) (access June 2010).
- 2273 Heinemann JA (2007) A typology of the effects of (trans)gene flow on the conservation and sustainable
2274 use of genetic resources. Food and Agriculture Organization (FAO), Background Study Paper no. 35 rev.
2275 1, 100 pp. Available at <ftp://ftp.fao.org/ag/cgrfa/bsp/bsp35r1e.pdf> (access July 2010).
- 2276 Hill RA (2005) Conceptualizing risk assessment methodology for genetically modified organisms.
2277 Environ. Biosafety Res. 4: 67-70. Available at [http://bch.cbd.int/database/record-](http://bch.cbd.int/database/record-v4.shtml?documentid=41660)
2278 [v4.shtml?documentid=41660](http://bch.cbd.int/database/record-v4.shtml?documentid=41660) (access June 2010).
- 2279 Hokanson K, Quemada H (2009) Improving risk assessment – problem formulation and tiered testing.
2280 Presented at SEARCA Agriculture and Development Seminar Series, 28 April 2009. Available at
2281 <http://bch.cbd.int/database/record-v4.shtml?documentid=101212> (access June 2010).
- 2282 ICGEB (website) International Centre for Genetic Engineering and Biotechnology. Available at
2283 <http://www.icgeb.org/~bsafesrv/introduction/generalintro.html> (access October 2013).

- 2284 IUCN (2003) An Explanatory Guide to the Cartagena Protocol on Biosafety. Available at
2285 <http://bch.cbd.int/database/record-v4.shtml?documentid=41476> (access June 2010).
- 2286 Ministry of Environment and Energy Denmark (1999) Ecological Risk Assessment of Genetically
2287 Modified Higher Plants (GMHP) – Identification of Data Needs. Ministry of Environment and Energy,
2288 National Environmental Research Institute (NERI) Denmark. NERI Technical Report, No. 303, 35 pp.
2289 Available at http://www2.dmu.dk/1_viden/2_Publikationer/3_fagrappporter/rapporter/fr303.pdf (access
2290 July 2010).
- 2291 OECD (2006) Guidance for the Designation of a Unique Identifier for Transgenic Plants. Available at
2292 <http://bch.cbd.int/database/record-v4.shtml?documentid=101186> (access June 2010).
- 2293 OGTR (2013) Risk Analysis Framework 2013, Australia. Office of the Gene technology Regulator,
2294 Department of Health and Aging, Australian Government. Available at
2295 [http://www.ogtr.gov.au/internet/ogtr/publishing.nsf/content/42D3AAD51452D5ECCA2574550015E69F/
2296 \\$File/raffinal5_2.pdf](http://www.ogtr.gov.au/internet/ogtr/publishing.nsf/content/42D3AAD51452D5ECCA2574550015E69F/$File/raffinal5_2.pdf) (accessed December 2013).
- 2297 SCBD (2012) Guidance on Risk Assessment of Living Modified Organisms. Final Report of the Ad Hoc
2298 Technical Expert Group on Risk Assessment and Risk Management under the Cartagena Protocol on
2299 Biosafety, UNEP/CBD/BS/AHTEG-RA&RM/4/6. Available at
2300 <http://bch.cbd.int/protocol/meetings/documents.shtml?eventid=5037> (access August 2012).
- 2301 The European Parliament and the Council of the European Union (2001) Directive 2001/18/EC of the
2302 European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment
2303 of genetically modified organisms and repealing Council Directive 90/220/EEC. Available at [http://eur-
2304 lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32001L0018:EN:HTML](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32001L0018:EN:HTML) (access June 2010).
- 2305 Underwood E, Poláková J, Berman S, Dooley E, Freluh-Larsen A, Kretschmer B, Maxted N, McConville
2306 AJ, Naumann S, Sarteel M, Tostivint C, Tucker GM, van der Grijp NM (2013) Technology options for
2307 feeding 10 billion people. Climate change and agriculture; biodiversity and agriculture. Report prepared
2308 for the STOA Panel of the European Parliament. Contract IP/A/STOA/FWC/2008-096/LOT3/C1/SC5.
2309 Institute for European Environmental Policy, BIO Intelligence Service, Ecologic Institute, IVM,
2310 Brussels/London. Available at
2311 [http://www.europarl.europa.eu/RegData/etudes/etudes/join/2013/513514/IPOL-
JOIN_ET\(2013\)513514\(ANN01\)_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/etudes/join/2013/513514/IPOL-
2312 JOIN_ET(2013)513514(ANN01)_EN.pdf) (access December 2013).
- 2313 UNEP (1995) International Technical Guidelines for Safety in Biotechnology. United Nations
2314 Environment Programme (UNEP). Available at [http://bch.cbd.int/database/record-
2315 v4.shtml?documentid=42114](http://bch.cbd.int/database/record-v4.shtml?documentid=42114) (access June 2010).
- 2316 UNEP Division of Technology, Industry and Economics (website) Technical Workbook on
2317 Environmental Management Tools for Decision Analysis. Available at
2318 <http://www.unep.or.jp/ietc/publications/techpublications/techpub-14/1-EnRA3.asp> (access June 2010).
- 2319 UNEP/IPCS (1994) Training module No. 3. Section C – Ecological risk assessment. United Nations
2320 Environment Programme (UNEP) / International Programme on Chemical Safety (IPCS), pp 177-222.
2321 Available at <http://www.chem.unep.ch/irptc/Publications/riskasse/C2text.pdf> (access July 2010).

- 2322 US Environmental Protection Agency (1998) Guidelines for Ecological Risk Assessment. EPA/630/R-
2323 95/002F. Available at http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=36512 (access June
2324 2010).
- 2325 WHO (2004) IPCS Risk Assessment Terminology. Part 2: IPCS Glossary of Key Exposure Assessment
2326 Terminology. World Health Organization (WHO). Available at
2327 <http://www.inchem.org/documents/harmproj/harmproj/harmproj1.pdf> (access June 2010).