PART 1

CONTRIBUTED PAPERS
ON
UNDERSTANDING AND APPLYING RISK ANALYSIS IN AQUACULTURE

General principles of the risk analysis process and its application to aquaculture

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ABSTRACT

Governments and the private sector must often make decisions based on incomplete knowledge and a high degree of uncertainty and where such decisions may have far-reaching social, environmental and economic consequences. Risk analysis is a process that provides a flexible framework within which the risks of adverse consequences resulting from a course of action can be evaluated in a systematic science-based manner. It permits a defendable decision to be made on whether a particular risk is acceptable or not, and the means to evaluate possible ways to reduce a risk from an unacceptable level to one that is acceptable.

Risk analysis is now widely applied in many fields, for example, in decisions about risks due to chemical and physical stressors (natural disasters, climate change, contaminants in food and water, pollution, etc.); biological stressors (human, plant and animal pathogens; plant and animal pests; invasive species, invasive genetic material); social and economic stressors (public security (including risk of terrorism), construction and engineering (building safety, fire safety, military applications), and business (project operations, insurance, litigation, credit, cost risk maintenance, etc.).

The general framework for risk analysis consists of four major components:

- Hazard identification – the process of identifying hazards that could potentially produce consequences.
- Risk assessment – the process of evaluating the likelihood that a potential hazard will be realized and estimating the biological, social and/or economic consequences of its realization.
- Risk management – the seeking of means to reduce either the likelihood or the consequences of it going wrong; and
- Risk communication – the process by which stakeholders are consulted, information and opinions gathered and risk analysis results and management measures communicated.

Some basic principles that appear to be common to all types of risk analysis include those of common sense, uncertainty, precaution, objectivity, transparency, consistency, scientific validation, stakeholder consultation, stringency, minimal risk management, unacceptable risk and equivalence.

Risk analysis has wide applicability to aquaculture. It has mainly been applied in assessing risks to society and the environment posed by hazards created by or associated with aquaculture development. These include the risks of environmental degradation; introduction and spread of pathogens, pests and invasive species; genetic impacts; unsafe foods; and negative social and economic impacts. The use of risk analysis can provide insights and assist in making decisions that will help to avoid such negative impacts, thus helping aquaculture development to proceed in a more socially and environmentally responsible manner.

Risk analysis is less commonly used to achieve successful and sustainable aquaculture by assessing the risks to aquaculture posed by the physical, social and economic environment in which it takes place. These include reduction of environmental risks (e.g. due to poor siting or severe weather events), biological risks (infection by pathogens via transfer from native stocks, predation by seals and sharks; red tides, etc.), operational risks (poor planning, work-related injuries), financial risks (e.g. market changes, currency fluctuations, emergence of new competitors, etc.) and social risks (negative image and resulting product boycott, lack of skilled manpower, competition from other sectors).

There exists, therefore, considerable scope to develop and expand the use of risk analysis for the benefit of aquaculture and the social and physical environments in which it takes place.

INTRODUCTION

Governments and the private sector must often make decisions based on incomplete knowledge and a high degree of uncertainty. Such decisions may have far-reaching social, environmental and economic consequences. Risk analysis is a process that provides a flexible framework within which the risks of adverse consequences resulting from a course of action can be evaluated in a systematic, science-based manner. The risk analysis approach permits a defendable decision to be made on whether the risk posed by a particular action or "hazard" is acceptable or not, and provides the means to evaluate possible ways to reduce the risk from an unacceptable level to one that is acceptable.

Risk analysis is now widely applied in many fields that touch our daily lives. These include decisions about risks due to chemical and physical stressors (natural disasters, climate change, contaminants in food and water, pollution etc.), biological stressors (human, plant and animal pathogens; plant and animal pests; invasive species, invasive genetic material), social and economic stressors (unemployment, financial losses, public security, including risk of terrorism), construction and engineering (building safety, fire safety, military applications) and business (project operations, insurance, litigation, credit, cost risk maintenance etc.). Risk analysis is thus a pervasive but often unnoticed component of modern society that is used by governments, private sector and individuals in the political, scientific, business, financial, social sciences and other communities.

THE CONCEPT OF RISK

The definition of "risk" varies somewhat depending on the sector. Most definitions incorporate the concepts of:

- uncertainty of outcome (of an action or situation),
- probability or likelihood (of an unwanted event occurring), and
- consequence or impact (if the unwanted event happens).

Thus "risk" is the potential for realization of unwanted, adverse consequences to human life, health, property or the environment. Its estimation involves both the likelihood (probability) of a negative event occurring as the result of a proposed action and the consequences that will result if it does happen. As an example, taken from pathogen risk analysis, the *Aquatic Animal Health Code* (OIE, 2007) defines risk as:

"Risk – means the likelihood of the occurrence and the likely magnitude of the consequences of an adverse event to public, aquatic animal or terrestrial animal health in the importing country during a specified time period."

While some sectors incorporate consideration of potential benefits that may result from a "risk" being realized (e.g. financial risk analysis), others specifically exclude benefits from being taken into account (e.g. pathogen risk analysis).

WHAT IS RISK ANALYSIS?

"Risk analysis" is usually defined either by its components and/or its processes. The Society for Risk Analysis www.sera.org offers the following definitions of "risk analysis":

- a detailed examination including risk assessment, risk evaluation and risk management alternatives, performed to understand the nature of unwanted, negative consequences to human life, health, property or the environment;
- an analytical process to provide information regarding undesirable events;
- the process of quantification of the probabilities and expected consequences for identified risks.

In can also be defined as *an objective, systematic, standardized and defensible method of assessing the likelihood of negative consequences occurring due to a proposed action or activity and the likely magnitude of those consequences*, or, simply put, it is "*science-based decision-making*".

The risk analysis process

In simple terms, a risk analysis typically seeks to answer four questions:

- What can go wrong?
- How likely is it to go wrong?
- What would be the consequences of its going wrong?
- What can be done to reduce either the likelihood or the consequences of its going wrong? (see MacDiarmid, 1997; Rodgers, 2004; Arthur *et al*., 2004).

The general framework for risk analysis typically consists of four major components:

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- Risk management – the seeking of means to reduce either the likelihood or the consequences of it going wrong; and
- Risk communication – the process by which stakeholders are consulted, information and opinions gathered and risk analysis results and management measures communicated.

The risk analysis process is quite flexible. Its structure and components will vary considerably depending on the sector (e.g. technical, social or financial), the user (e.g. government, company or individual), the scale (e.g. international, local or entity-level) and the purpose (e.g. to gain understanding of the processes that determine risk or to form the basis for legal measures). It can be qualitative (probabilities of events happening expressed, for example, as high, medium or low) or quantitative (numerical probabilities).

THE CONCEPT OF "HAZARD"

All risk analysis sectors involve the assessment of risk posed by a threat or "hazard". The definition of "hazard" depends on the sector and the perspective from which risk is viewed (e.g. risks **to** aquaculture or risks **from** aquaculture). A hazard thus can be:

- a physical agent having the potential to cause harm, for example:
  - a biological pathogen (pathogen risk analysis);
  - an aquatic organism that is being introduced or transferred (genetic risk analysis, ecological risk analysis, invasive alien species risk analysis);
  - a chemical, heavy metal or biological contaminant (human health and food safety risk analysis, environmental risk analysis); or
- the inherent capacity or property of a physical agent or situation to cause adverse affects, as in
- social risk analysis,
- financial risk analysis, and
- environmental risk analysis.

Risk analysis terminology

The terminology used by some risk analysis sectors is well established (e.g. pathogen risk analysis, food safety, environmental risk analysis), and there is often considerable differences in how individual terms are defined. An attempt at cross-sectoral standardization of terms is thus probably futile, and it is thus important that that terms used by the various risk analysis sectors be fully defined at the outset.

SOME GENERAL PRINCIPLES

Some basic principles that appear to be common to all types of risk analysis are presented below. These involve the broader concepts of common sense, uncertainty, precaution, objectivity, transparency, consistency, scientific validation, stakeholder consultation, stringency, minimal risk management, unacceptable risk and equivalence.

- **The Principle of Common Sense** – In assessing risks, the use of "common sense" should prevail. In many cases, the outcomes of a risk analysis are obvious and uncontroversial, and a decision can be made without resulting to a full risk analysis, which can be a lengthy and expensive process.
- **The Principle of Uncertainty** – All risk analyses contain an element of uncertainty. A good risk analysis will seek to reduce uncertainty to the extent possible.
- **The Principle of Precaution** – Those involved in the aquaculture sector have a responsibility to err on the side of caution, particularly if the outcomes of a given action may be irreversible. If the level of uncertainty is high, the Precautionary Principle can be applied to delay a decision until key information is obtained. However, steps must be taken to obtain the information in a timely manner.
- **The Principle of Objectivity** – Risk analyses should be conducted in the most objective way possible. However, due to uncertainty and human nature, a high degree of subjectivity may be present in some risk analyses. A risk analysis should clearly indicate where subjective decisions have been made.
- **The Principle of Transparency** – Risk analyses, particularly those conducted by public sector agencies, should be fully transparent, so that all stakeholders can see how decisions were reached. This includes full documentation of all data, sources of information, assumptions, methods, results, constraints, discussions and conclusions.
- **The Principle of Consistency** – Although risk analysis methodology continues to evolve, it is important that decisions, particularly those made by government, are reached via standardized methods and procedures. In theory, two risk analysts independently conducting the same risk analysis should reach roughly similar conclusions.
- **The Principle of Scientific Validation** – The scientific basis of a risk analysis and the conclusions drawn should be validated by independent expert review.
- **The Principle of Stakeholder Consultation** – If the results of a risk analysis are likely to be of interest to, or impact upon others, then stakeholder consultations

should be held. This is accomplished by risk communication, the interactive exchange of information on risk among risk assessors, risk managers and other interested parties. Ideally, stakeholders should be informed/involved throughout the entire risk analysis process, particularly for potentially contentious risk analyses (e.g. ecological, genetic and pathogen risk analyses for the introduction of new aquatic species).

- **The Principle of Stringency** – The stringency of the risk management measures to be applied should be in direct proportion to the risk involved.
- **The Principle of Minimal Risk Management** – Risk management measures that impinge on the legitimate activities of others should be applied only to the extent necessary to reduce risk to an acceptable level.
- **The Principle of Unacceptable Risk** – If the level of risk is unacceptable and no effective or acceptable risk management measures are possible, then the activity should not take place.
- **The Principle of Equivalence** – Risk management measures proposed by trading partners that meet the acceptable level of risk should be accepted by the importing country.

APPLICATION OF RISK ANALYSIS TO AQUACULTURE

Risk analysis has wide applicability to aquaculture. So far, it has mainly been applied in assessing risks to society and the environment posed by hazards created by or associated with aquaculture development (Box 1). These include the risks of environmental degradation; introduction and spread of pathogens, pests and invasive species; genetic impacts; unsafe foods; and negative social and economic impacts. The use of risk analysis can provide insights and assist in making decisions that will help to avoid such negative impacts, thus helping aquaculture development to proceed in a more socially and environmentally responsible manner.

Risk analysis is less commonly used to achieve successful and sustainable aquaculture by assessing the risks to aquaculture posed by the physical, social and economic environment in which it takes place Box 2. These include reduction of environmental risks (e.g. due to poor siting or severe weather events), biological risks (infection by pathogens via transfer from native stocks, predation by seals and sharks; red tides etc.), operational risks (poor planning, work-related injuries), financial risks (e.g. market changes, currency fluctuations, emergence of new competitors, etc.) and social risks (negative image and resulting product boycott, lack of skilled manpower, competition from other sectors).

There exists, therefore, considerable scope to develop and expand the use of risk analysis for the benefit of aquaculture and the social and physical environments in which it takes place.

BOX 1

Examples of risks to society from aquaculture

Environmental risks
- pollution from feeds, drugs, chemicals, wastes
- alteration of water currents & flow patterns

Biological risks
- introduction of invasive alien species, exotic pests & pathogens
- genetic impacts on native stocks
- destruction/modification of ecosystems and agricultural lands (mangrove deforestation, salination of ricelands)

Financial risks
- failure of farming operations
- collapse of local industry/sector

Social risks
- displacement of artisanal fishers

Human health risks
- food safety issues

CONCLUSIONS

An integrated approach to risk analysis will assist the aquaculture sector in reducing risks to successful operations from both internal and external hazards and can similarly help

BOX 2

Examples of risks to aquaculture from society and the environment

Environmental risks
- severe weather patterns
- pollution (e.g. agricultural chemicals, oil spills)

Biological risks
- pathogen transfer from wild stocks
- local predators (seals, sharks etc.)
- toxic algal blooms, red tide

Operational risks
- poor planning
- poor design
- workplace injuries

Financial risks
- market changes
- inadequate financing
- currency fluctuations
- emergence of new competitors

Social risks
- negative image/press
- lack of skilled manpower
- competition for key resources from other sectors
- theft, vandalism

to protect the environment, society and other resource users from adverse and often unpredicted impacts. This could lead to improved profitability and sustainability of the sector, while at the same time improving the public's perception of aquaculture as a responsible, sustainable and environmentally friendly activity.

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