Integrated Water Cycle Management in Kazakhstan

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Textbook developed in the TEMPUS IV – 5th Call of Proposals on Joint Projects

I-WEB™

Almaty

"Qazag university"

2014

Editors:

Burghard C. Meyer & Lian Lundy,

The publication should be citated as follows

Meyer B. C. & L. Lundy (Eds). 2014. Integrated Water Cycle Management in Kazakhstan. Al-Farabi Kazakh National University, Publishing House, Almaty, 320 pages

ISBN: 978-601-04-0900-2

Published with active contributions of the TEMPUS IV IWEB-Project partner's institutions:

- Middlesex University, London, UK
- Al-Farabi Kazakh National University, Almaty, Kazakhstan
- Ahmed Yasawi International Kazak-Turkish University, Turkistan, Kazakhstan
- Kokshetau State University named after Shokan Ualikhanov, Kokshetau, Kazakhstan
- Universität Leipzig, Germany
- Universitat Politecnica de Valencia, Spain
- University of Cyprus, Nicosia, Cyprus
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- Ministry of Education and Science Control Committee, Astana, Kazakhstan
- Center of Bologna process and academic mobility, Astana, Kazakhstan
- Fund Zhas Otan, Akmola region, Kokshetau, Kazakhstan

Cover page photographs: Burghard Meyer

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Introduction

Integrated Water Cycle Management in Kazakhstan – introduction to content and use

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The 'Integrated Water Cycle Management (IWCM) in Kazakhstan' book is specifically designed to support Kazakh students and teachers to develop the broad knowledge base required to underpin a critical understanding of international best practice in water resource management. It innovatively integrates knowledge developed in international, European and Kazakh science and engineering about how to sustainably manage this finite resource with a clear focus on understanding and addressing the human challenges currently facing Kazakhstan and the Central Asian region through stakeholder engagement, risk communication and policy development.

Even the briefest consideration of the water management reveals its complexity. Conflict over water has a long history and is likely to get worse as populations increase, climate changes and demands on transboundary water bodies escalate. Great harm has been done in the past and major work needs to be done in the future to repair previous damages and ensure a sustainable future supply of water. There are huge political and resource issues and opinions are characteristically divided at almost every stage of water management decision-making. Addressing the challenges of this complexity and magnitude is clearly beyond the scope of any single individual or even country. All too frequently both individuals and nations operate in 'mental silos', based on what their training is, who they work for and what their responsibilities are. This effectively isolates them from both those who are impacted by their activities and also those who decisions, in turn, impact on them.

So what are students to make of this? Traditionally at the start of their career, graduates usually do not yet know what demands their profession will require and they may go on to be employed in a variety of roles throughout their professional life e.g. in industry, science, administration or regulation. The degree of specialisation between, say, an engineer and an analytical chemist mean that they may be taught subjects that appear remote from each other. Other professions may never undertake a technical role but may be required to set objectives or develop policy that needs to be underpinned by high quality science and to be cognisant of the wider socio-economic implications of such activities. So it is clear that there is an interaction between those responsible for policy and management and those working to gather data. Students on an integrated course will have an important opportunity to study all aspects of the functions of water management, which will give important insights and develop essential skills to help them co-operate with each other later, whatever their own role turns out to be.

IWCM is considered to be international best practice with regard to enabling water resources to meet the needs of current and future generations. The central concept is the development and application of objectives in the form of regional and national catchment-based goals for water management based on the changing natural conditions and water usages. It includes the development of knowledge about ground and surface water quality and quantity, evaluation of water resource policy over a long-term perspective, implementation of plans and actions that have been developed collaboratively by all water users and the on-going monitoring and evaluation of all processes (see Figure 1).

Implementation of IWCM includes the protection of the environment by avoiding over use and/or the deterioration of water resources. It requires the development and modernization of institutional structures, methods, legislation and norms. In achieving these ambitious objectives, the knowledge of a range of management instruments and 'softer skills' such as team working and written and oral presentation skills are crucial components for the successful application of a range of modern best practice methods and technologies.

Overview of contents

The opening section of this textbook shows how a risk governance framework can be used to link technical evidence with stakeholder requirements to support development of an integrated approach to policy development and implementation, meeting the associated requirements for optimal utilisation of skills and resources.

To facilitate students and teachers in developing skills in and undertaking self learning in the complex and interdisciplinary field of IWCM in Kazakhstan, this textbook is structured into seven themed chapters as follows:

Figure 1 Integrated Water Cycle Management (IWCM) as developed by the International Network of Basin Organizations (INBO) in 2009

1. Selected concepts in IWCM;
2. Methodologies and supporting tools for IWCM;
3. Management skills for building capability, capacity and impact;
4. Best practice examples for water treatment management;
5. Sustainable use of water resources in Kazakhstan;
6. Integrative Water Cycle Management in Kazakhstan;
7. Transboundary catchment issues and future integrated management.

Finally the Appendix includes a glossary containing definitions of key terms from the diverse and interdisciplinary field of IWCM and an index for easy orientation and access to information on particular terms of interest within the text.

The textbook starts by introducing readers to general principles, methodologies and management skills underpinning a successful IWCM approach (see chapters 1-3). These general basics are then further developed with reference to best practice examples for water treatment and water production developed in Europe and Kazakhstan (see chapter 4). Chapter 5 introduces and then applies, in multiple interdisciplinary examples, the current Kazakh perspective on the sustainable use of water resources, defining key aspects and data gaps to be addressed to enable its transition to an IWCM approach. Chapters 6 and 7 clarify current water management practices in Kazakhstan within the context of a European Water Framework Directive approach, and focus on the need to robustly address transboundary catchment planning and integrated water management issues throughout both the Central Asian and European regions. The textbook is organised to enable the reader to self-organise their learning and to identify the concepts, tools and aspects that are essential for problem-solving in the field of IWCM.

Chapter 1 presents an overview of **IWCM concepts.** It discusses water bodies as providers of multiple ecosystem services, goods and benefits, the basics of the microbial pollution of water, urban water cycle aspects including water supply, wastewater and urban stormwater best management practices, the basics of maintaining minimal water flows and levels in surface and groundwater and the use of soils as indicators for degradation processes associated with the characteristics of surface water runoff they receive.

Chapter 2 on **methodologies and supporting tools for IWCM** introduces the concept of strategic risk management, including risk assessment methods for land use optimisation on the basis of simple predictive models. The use of models and Decision Support Systems (DSS) in association with modern technologies and scientific data sets are key features of IWCM. Therefore, the use of models and simulation methods are introduced as the best practice basis for the optimization of water resource systems. The use of an integrated water resource planning and management DSS is demonstrated for the management of water quality, water quantity aspects, environmental issues, conflict resolutions and drought risk assessment. Further, the development and implementation of robustly-designed sampling and monitoring strategies are evaluated as the basis for informing and assessing levels of success of IWCM approaches implemented.

Chapter 3 introduces **management skills for building capability, capacity and impact**. It enables the reader to learn how to undertake a successful literature search and literature review,

as well as ways to manage and analyse data. The use of Geographical Information Systems (GIS) is currently the basis of water management activities in many areas of the world and, together with meta-analysis approaches, gives practitioners and scientists from a diversity of sectors a powerful tool for finding and integrating data layers to better inform decision-making. An introduction to basin planning shows the importance of stakeholder participation – that working in partnership is essential to address risks facing society today and in the future. Therefore the development of project and management skills in general is of crucial importance for the successful application of IWCM. It is stressed that management of water resources must be planned and implemented using a long term perspective. This includes beginning to plan for the future now by for example, identifying the general and specialist competences required in education for sustainable development and putting in place mechanisms to ensure current and emergent graduate cohorts are able to develop these competences.

Chapter 4 demonstrates **best practice examples for water treatment management** including the management of urban wastewater treatment processes, drinking water purification technologies and monitoring of water quality, the sources and occurrence of pharmaceutical residues in the aquatic environment and the removal of pharmaceuticals from aqueous matrices by biological and advanced chemical oxidation processes. These best practice examples give further opportunities to enhance understanding of the potential implications related to wastewater reuse, the industrial production of bottled natural mineral, drinking and medicinal water and suitable methods for the treatment of industrial wastewaters. The examples focus on the removal of heavy metals using electrochemical methods of wastewater treatment and current methods for the cleaning, neutralization and utilization of wastewater generated by Kazakhstan industries.

Chapter 5 introduces the s**ustainable use of water resources in Kazakhstan.** The chapter starts with a description of the basic characteristics of Kazakh water resources in the context of sustainable development and general theories about human and climate-related degradation processes impacting on hydrological resources. An overview of long-term climate change studies and its impacts under various scenarios is given, together with data on its groundwater resources within the context of the national economy. An overview of the physical and chemical properties of water systems within the territory of Kazakhstan is also presented. An analysis of lakes is given with a focus on the hydrophysics, hydrochemistry and hydrobiology of the Large Aral Sea and the undrained Lake Balkhash, together with information on the lakes of Northern Kazakhstan. The biological and agricultural perspective of IWCM is given through an overview of the current state of fishery stocks and the biological screening of polluted water systems. The chapter concludes with an introduction to the need for an IWRM approach within Kazakhstan's irrigation systems.

Chapter 6 on **Integrated Water Cycle Management for Kazakhstan** starts with an introduction on the current status of the application of the European Water Framework Directive (EU WFD) as opportunity for readers to learn about successes and failures from European organisational and application perspectives. The implementation of river catchment scale management plans and associated structures at a national and local catchment scale is demonstrated, and the administrative and management authorities in Kazakhstan on catchment and IWCM issues are explained.

Chapter 7 focuses on **transboundary catchment issues and the future of integrated water resource management.** Transboundary mountain ecosystems and the current situation with regard to the development of bio-resources of the transboundary rivers Ili and Irtysh in Kazakhstan are presented as pertinent examples which clarify selected aspects of transboundary issues. The challenges of transboundary cooperation with regard to the need for integration across and within policy, administration, and industry sectors are discussed. The textbook concludes with a discussion on the management practices and challenges for Central Asia within the context of fully implementing an EU WFD basin management approach.

An introduction to water management in Kazakhstan in the context of integrated risk management

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Introduction

Managing any complex risk, in this case water, can be seen as a conversation (frequently an argument) between those responsible for policy and management and those working as engineers and scientists to gather data. In addition, this professional conversation takes place under the intense scrutiny of public expectations and legal requirements. No situation is the same – the characteristics of the site and the political context of stakeholder expectations vary enormously.

For all of these reasons it is useful to try to find a way of linking all of the components together in a manner that integrates the various functions and shows the relationship between them. The concept of risk governance (IRGC, 2005, Renn, 2008, Renn and Walker, 2008) offers a useful framework that can be used for this purpose. Chapter 2.1 discusses the origin of such approaches and introduces the idea of a conversation between two 'sides' (risk management and risk assessment), which suggests that clarity in definition of the functions of both is useful in identification of who is responsible for any given task, what their mandate is and when (and to whom) they should communicate their findings. Policy makers (a risk management function) are general managers who need to take care of many interrelated issues, so they are generalists. Frequently they may require evidence on which to base their evaluation and so they need input from scientists and engineers (for assessment of the risk and of stakeholder concerns).

Despite what either group may privately believe, the generalists cannot do without the specialists since they lack expertise in the area and the technical people cannot make policy on their own since sustainable policy requires the inclusion of values. The technical concepts required for water management in Kazakhstan that are presented in Chapter 6 cannot simply be turned into policy without consideration of costs and benefit, acceptable levels or stakeholder agendas (including those of the government itself).

Integration at strategic level

It is sensible to look at the management of water in Kazakhstan within the wider context of the whole process of management. As with all risk management, water cycle management does not operate in a vacuum – it is undertaken in pursuit of certain benefits, which vary from place to place. It is constrained by the finite resources available and is required to meet certain societal aims (as well as legal obligations).

There are two main things that can obstruct such developments – *uncertainty* and *conflict*. There is never enough information and people rarely agree, which means that judgements need to be made with imperfect knowledge and a consensus established, which agrees on the way forward. The process therefore involves both evidence and values, and both are important. Figure 2 shows that, at its simplest, risk management at this

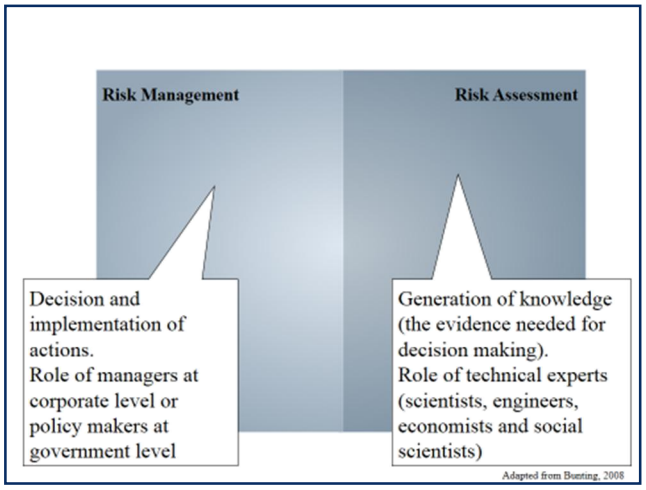


Figure 2 The relationship between management and assessment for strategic level risk management

strategic level can be divided into two parts – risk assessment and risk management.

In this scheme *risk management* can be seen as looking after values (the reasons why the water is being managed) and making the decisions about the way to mitigate, control and otherwise manage risks that threaten the sustainable maintenance of a supply of safe water for the all the various requirements of Kazakh society (drinking, irrigation, sanitation, recreation etc.). Sections 2.5 and 2.6 resent some modern Information Technology based decision support for this function. *Risk assessment* gathers the evidence available to support the decision making process, for example monitoring of water quality (see

section 2.8). Public values and social concerns may act as driving agents for identifying those topics for which risk assessments are judged necessary or desirable.

Risk governance of water

The process of decision making, sometimes called *risk governance*, is important as, done competently and transparently, it contributes to the trust placed in it.

The framework (Figure 3, adapted from IRGC, 2005) separates the process of risk governance into a number of different elements that make the process easier to understand. It is important to stress that this is a *functional* separation; it may actually be carried out by the same individuals in some circumstances. A scientist, for example, may be analysing water in the laboratory on one day (risk assessment) and participating in a strategy development meeting on another day (risk management). Discussion of the two 'sides' below, therefore, refers to the *functions* of risk management and risk assessment.

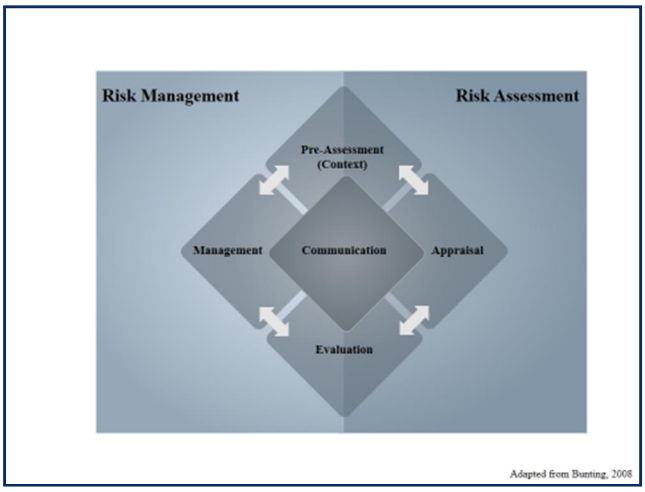


Figure 3 Overview of the functions of risk governance at strategic level

The first stage discusses ways that the local context can be established with a clear recognition of the benefits of the water being managed. This is best undertaken by both sides together, and Chapter 5 raises and discusses a number of important issues for sustainable use of water resources in Kazakhstan, showing that the issues can be approached from many perspectives – physical (e.g. hydrology, climate, ecology) and human (e.g. sustainability, economy, use to which resources are devoted). The context includes the legal and regulatory framework within which the water system needs to operate, as discussed in Chapter 6.

Secondly the process of gathering data is discussed, for example in the risk assessments sections in Chapter 2. These data may relate not only to the scientific and technical assessment of the water supply and its quality but also to an assessment of public concern (both in the light of recent incidents but also consideration of their general expectation of the manner in which the water resources are managed). This is normally a technical operation requiring a trained person to undertake it (who may be part of an in-house capability or a consultant).

The third stage is again best undertaken by both 'sides', since it is the place where the evidence from the risk appraisal is evaluated in the light of the organisational values set out in the first stage. This considers the adoption of one of three possible management actions – do nothing, ban some proposed or current activity or manage the risk. It addresses the difficult task of deciding 'how safe is safe enough' in the light of statutory duties, available resources and achievement of management goals to optimise the benefits of the water resource. Useful benchmarks can be developed from reviews of what others have done (see Chapter 4 for a number of examples). Sustainable requires the integration of values into decision making and a number of issues are discussed in Chapter 5, with specific attention paid to the context of Kazakhstan. The latter chapter shows that scientific evidence needs to be evaluated in the light of dynamic changes in social and political contexts as well as incorporating environmental and climate change.

The fourth stage, logically, focuses on generating and evaluating management options. It is the responsibility of those charged with managing the region, who need to set a policy that will protect the water and the people that use it. Chapter 6 presents the EU context and evaluates a number of integrated approaches in at different scales in Kazakhstan and Chapter 7 discusses some of the major challenges that need to be tackled in the future especially from a trans boundary and international perspective.

The fifth element of risk governance deals with risk communication, which is placed in the centre of all of the other activities to highlight its importance. Communication is a means by which those involved with the various parts of the process

understand what is happening, how they are involved and, where appropriate, what their responsibilities are – this can be called internal risk communication. It is also important to ensure that people outside the process are informed and engaged (external risk communication).

The framework is presented as if the various functions take place one after the other but, in practice, a great deal of the process will already be in place. The context setting does not always take place before the assessment but logically it should be at the forefront of assessment and management. The various elements can be seen as interlinked rather than sequential. The framework identifies four major tasks.

Task 1 Context Setting

The first task (sometimes known as *pre-assessment,* Figure 4) can be broken down into a number of different steps – framing, early warning, screening and selection of conventional and procedural rules needed for risk assessment.

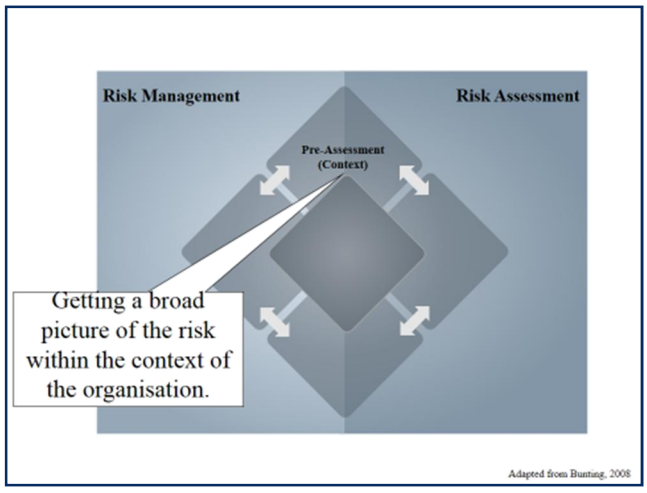


Figure 4 Integrated risk governance - part 1, pre-assessment.

It is important at the outset to establish the reason for managing different water resources. What are they for? This step places the benefits of water resources at the forefront of the entire process[1]. It also permits the managers to ask good questions of the risk assessment process and to establish the values by which the evidence collected will be evaluated. Environmental or safety interventions may have consequences that put other benefits of water at risk and will therefore need to be appraised in the specific local context. If some of the water being managed, for example, is designated for irrigation it may threaten drinking water supply downstream. Section 5.9 for example, highlights the impact of water extraction for industry and agriculture has on fisheries (and the political complication when the extraction takes place in another country). It is clear that there may be different ways that things may be selected as risks. This is known as *'framing'* and the risks selected depend on getting agreement about the underlying goal and the implications of various hazards.

Another, frequently implicit, function of context setting is *early warning and monitoring.* A change in public perception about the use to which a water body is dedicated might influence the assessment and would be picked up by this horizon scanning activity.

The context setting phase also establishes a *risk assessment policy.* This will guide the risk assessment process by defining protocols for assessment and management, which will include methods of investigation and ways that the evidence will be used for evaluation. This may include a desire to survey stakeholder concerns, if these are not known, which can be helpful at the evaluation stage.

The last part of the context setting involves a consideration of the conventions and procedural rules to be used. If, for example, the decision of the risk assessment policy was to examine water quality in relation to drinking water supply, how will this calculation be performed? The context will also include ensuring that risk assessment includes collection of all the evidence needed to meet the statutory requirements. The review of Kazakh and EU legislation provided in Chapter 6 shows how such conventions may influence and constrain risk management.

Task 2 Risk Appraisal

This task gathers all the elements necessary for risk characterisation and evaluation. As shown in Figure 5 it has two major components:

[1] Concentrating on benefits from the outset may take the form of setting objectives for a particular resource or intervention, which address a specific need or agenda. It is difficult to develop a coherent plan for managing a resource until its underlying purpose has been agreed. This may, of course, also be keenly contested by different interest groups.

- Assessment of the risk in technical terms (based on engineering or science) and focussing on the factors identified in Task 1.
- Assessment of related concerns as well as social and economic implications. It is here that the legal and financial implications are calculated.

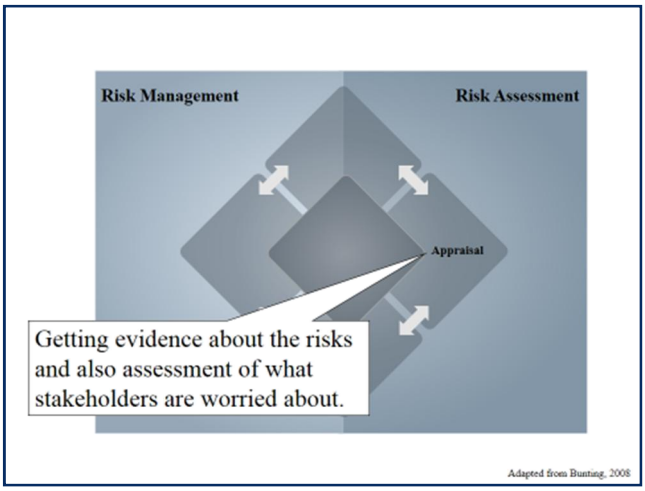


Figure 5 Integrated risk governance - part 2, risk appraisal

Risk assessment has a number of stages:

- Hazard identification and estimation (enough water? How much contamination?)
- Exposure/vulnerability assessment (how many people are exposed?)
- Risk estimation which can be quantitative (probability distribution of adverse effects, mapping of risk) or qualitative (a combination of hazard, exposure and qualitative factors)

The three stages are normally undertaken sequentially.

Risk assessment in the context of an individual organisation that owns or manages water resources therefore needs to examine supply or quality in line with an inspection regime established in the context setting phase.

Concern assessment gathers the evidence about the way that people perceive the risks to water supply and the implications for managing them. Different stakeholders will have very different agendas and may value water resources in completely different ways. This assessment of public concern may require survey or other approaches where specific information is seen as being useful. There is a useful discussion of partnership working in Section 3.6, which depends fundamentally on the ability to understand the different values and agendas that different groups support.

Task 3 Characterisation and Evaluation

This task (Figure) makes a judgement about the tolerability or acceptability of a given risk and utilises the data from the risk assessment phase with additional information from the concern assessment. The judgement relies on values and evidence and is made in the context of what society deems is acceptable or tolerable. This cannot be derived solely from an examination of the evidence but evidence is essential when making a judgement about whether a societal value has been infringed or not (and by how much). In some instances the criteria have already been set – for example water quality measurements may be compared to an existing standard to judge their acceptability. In many cases the judgement is less clear cut and may be contested by different groups of stakeholders.

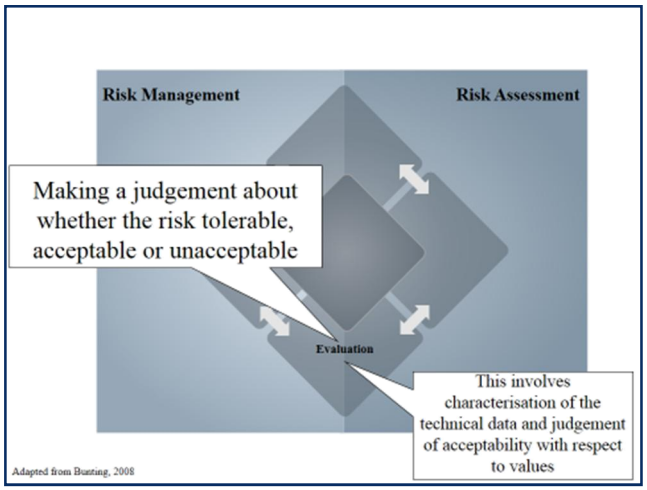


Figure 6 Integrated risk governance - part 3, characterisation and evaluation.

A tolerable risk is one worth pursuing for the benefit that it carries, though risks need to be managed. An acceptable activity is one where the remaining risks are so low that additional efforts for risk reduction are not seen as necessary. Human activities, however, influence the impact of natural hazards through changes in vulnerability and exposure.

The two parts of the task relate to the role of evidence and values in making sustainable decisions about the question of acceptable risk – which might be phrased as 'how safe is safe enough'? or 'how clean is clean enough'? *Risk characterisation* presents the evidence in terms of:

- Risk profile including:
  - Risk estimates (with confidence intervals and uncertainty measures where appropriate)
  - Hazard characteristics
  - Risk perceptions
  - Social and economic implications
- Risk severity including:
  - Compatibility with legal requirements
  - Risk : Risk trade-offs
  - Public Acceptance
- Conclusions and Options
  - Tolerable risk levels
  - Acceptable risk levels
  - Options for handling risks

Risk evaluation is the application of organisational (and societal) values and standards to the judgement of tolerability and acceptability. This will lead to an identification of options for transferring the risk or retaining and managing it. It reintroduces the consideration of the risk-benefit balance previously set out in the context setting. It may address the need to resolve conflicts.

A number of positions can be identified:

- Intolerable situation – where a risk source needs to be removed or, where that is not possible because of the loss of an important benefit, vulnerability needs to be reduced (perhaps by treatment) or exposure restricted.
- Tolerable situation – where risks need to be reduced as far as reasonably practicable. This situation occurs where the risk assessment has identified instances where the risk is deemed sufficient for action to be taken.
- Acceptable situation – where the risk is negligible and further risk reduction is not necessary.

As an example, Section 1.6 discusses ways to apply such concepts to the establishment of minimal and sustainable water flows.

Task 4 Risk management

This phase (Figure 7) starts with a review of the relevant information (evidence from the appraisal and judgements for the risk characterisation and evaluation) to form the basis for identification and selection of risk management options. A number of examples of good practice are reviewed in Chapter 4.

It seems sensible to focus on the task of risk management of tolerable risks (or risks whose tolerability is disputed) since the others are more

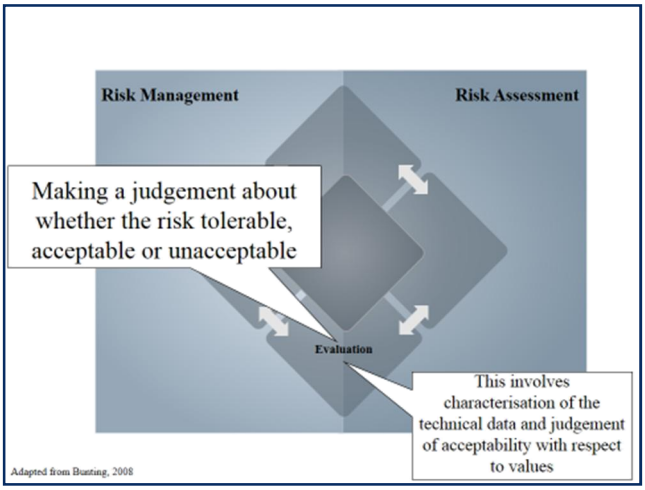


Figure 7 Integrated risk governance - part 4, risk management.

straightforward. There are a number of key stages that can be identified:

1. Identification of management options
2. Assessment of options against pre-defined criteria. These relate to the outcomes (intended or otherwise) on the control of the risk. The criteria might include:
   - Effectiveness
   - Efficiency
   - Sustainability
   - Side effects
   - Public acceptance
   - Political and legal implications
3. Evaluation of options. This is similar to risk evaluation in that a weight is given to the criteria based on the value judgements of the decision makers (on behalf of the organisation). It can be achieved by a co-operation between experts and managers (and might include stakeholder involvement in some cases).
4. Selection of options. The selection may be obvious or other tools such as cost-benefit analysis might be needed.
5. Implementation
6. Monitoring of performance.

The risk management stage would, of course, initiate action to deal with all of the risks facing the achievement of the management aims of the water resource identified in the first task.

It would also be important to evaluate (and monitor) the success of the interventions against the original values and objectives.

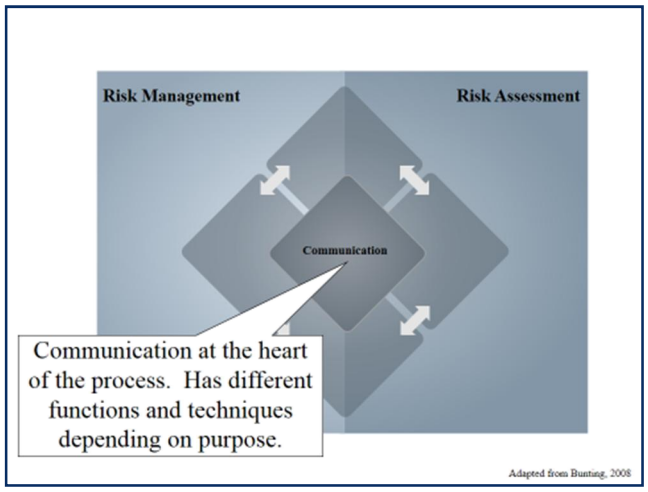


Figure 8 Integrated risk governance - part 5, risk communication

Risk Communication

The heart of this framework is communication and its importance cannot be underestimated (Figure 8) So frequently in the past risk communication has been seen as technical people telling people what to do and being totally bewildered when they seem to make decisions that fly in the face of evidence and be based on fear and emotion. Integration into a model of this type shows that there are many types of communication. Right at the outset it is important to understand what people actually want and need so that sensible objectives can be set. At the other end of the process technical evidence may suggest a solution to a problem and people may need to be persuaded to change their behaviour. Both instances require risk communication techniques but they are very different. Understanding of the underlying function of communication through appreciation of its role in risk governance can inform the best approach and enhance the integration of stakeholder values into the process with far reaching implication for sustainability of the outcome. People are far more likely to accept and implement solutions that they feel incorporate their values.

Decisions on risk are almost always made on the basis of perceived risk (and only sometimes is it possible to gain credible scientific justification). Policy may need to be established ahead of sufficient data being available and it is useful to have an agreed position (for example a political stance such as the precautionary principle) that frames the decision making.

Understanding what influences the perception of risk thus gains a major importance in risk governance. The role and influence of different stakeholders will also need to be analysed to optimise communication and management.

Conclusion

Establishing a risk governance structure of this type in practice is valuable for a number of reasons:

1. It demonstrates a process by which the risk is to be evaluated and managed.
2. It establishes an assessment policy by which that risk is appraised.
3. It listens to people's concerns.
4. It sets out and implements a risk management strategy based on evidence and values, including statutory requirements.
5. It monitors the effectiveness of that strategy (and amends it if it is ineffective).
6. It is benchmarked against industry and societal norms (environmental standards for example).

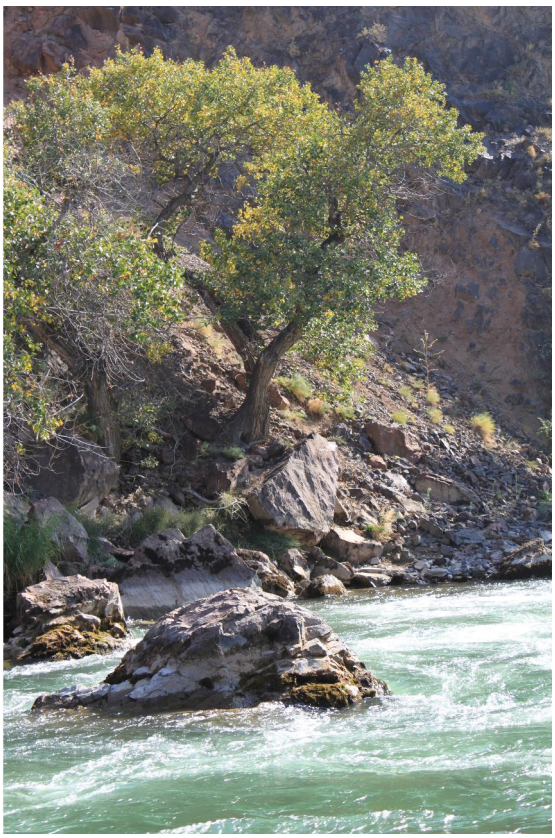
The main advantage of using a risk governance framework to frame the contents of the current textbook is that it permits students to understand the relationship between the various components that they need to study.

It permits them to understand that the complexity can be reduced by examination of the relationship between different stakeholders and their agendas, and that these can be examined by analysis of their influence on the functions of risk governance. Roles and responsibilities can be better understood and resources better directed to solving complex problems and building the consensus needed to acquire resources and change behaviour so as to obtain a sustainable solution.

Integrated Water Cycle Management
in Kazakhstan

IB No. 7535
Signed for publishing 01.10.14. Format 60x84 1/8. Offset paper.
Digital printing. Volume 25,41 printer's sheet.
Edition: 100. Order No.1824.
Publishing house "Qazag university"
Al-Farabi Kazakh National University, 71 Al-Farabi, 050040, Almaty
Printed in the printing office of the "Qazag university" publishing house

E-mail: baspa@kaznu.kz



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