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Global Water Partnership

IWRM ToolBox Teaching Manual

Global Water Partnership

ToolBox

Integrated Water Resources Management

www.gwptoolbox.org

About GWP

The Global Water Partnership (GWP) vision is for a water secure world.

Our mission is to advance governance and management of water resources for sustainable and equitable development. GWP is an international network that was created in 1996 to foster the implementation of integrated water resources management: the coordinated development and management of water, land, and related resources in order to maximise economic and social welfare without compromising the sustainability of ecosystems and the environment.

The GWP Network is open to all organisations which recognise the principles of integrated water resources management endorsed by the Network. It includes states, government institutions (national, regional, and local), intergovernmental organisations, international and national non-governmental organisations, academic and research institutions, private sector companies, and service providers in the public sector. The Network has 13 Regional Water Partnerships, 85 Country Water Partnerships, and more than 3,000 Partners located in 183 countries.

This publication was prepared by the Knowledge Management unit of GWP and jointly authored by a team of Professors from around the globe.

The views expressed in this document do not necessarily represent the official views of GWP.

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Acknowledgements

We gratefully acknowledge the work of Mr Kenge James Gunya, Knowledge Management Officer, and the following interns who helped to develop the concept of the document, coordinated the communication with authors, and co-edited the document: Brie Nelson, Sarah Perrine, Mario Roidt, and Mirja Schoderer. We also thank Monika Ericson, Senior Communications Officer, for coordinating the production work of this manual.

We further thank members of the GWP Technical Committee for their valuable comments and advice. We acknowledge Cap-Net UNDP for suggestions and sharing its experience from capacity development activities.

Editing, design and layout by Scriptoria: www.scriptoria.co.uk

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INTRODUCTION

Awareness of integrated water resources management (IWRM) has increased since it was coined and promoted in the 1990s. IWRM has been identified as a valuable process to encourage coordinated development and management of water, land, and related resources in order to maximise economic and social welfare in an equitable manner, without compromising the sustainability of vital ecosystems. In 2015, IWRM gained increased global political recognition through Goal 6 of the United Nation's Sustainable Development Goals. IWRM is specifically referred to in target 6.5 of the Sustainable Development Goals, to implement IWRM at all levels, including through transboundary cooperation as appropriate.

As IWRM is being increasingly implemented throughout the world, its relevance in university education is also increasing. Since 2000, the Global Water Partnership (GWP) has developed the GWP IWRM ToolBox as a free, open-access, knowledge-based resource. The IWRM ToolBox serves as an information exchange and learning platform where users are able to share their experiences and circulate knowledge in order to work towards a more cohesive implementation of IWRM. The IWRM ToolBox allows water-related practitioners and professionals to discuss and analyse the various elements of the IWRM process, and helps to prioritise actions aimed at improving water governance and management. Although the IWRM ToolBox is addressed to practitioners, it is also used by students and teachers to obtain up-to-date information for background research or other capacity-building exercises.

There has recently been high demand for additional training materials to accompany the IWRM ToolBox for the purpose of teaching in academia. Throughout 2013–2016, GWP conducted 14 IWRM ToolBox workshops attended by over 350 lecturers and students. The feedback received included requests for a manual to guide lecturers in using the GWP IWRM ToolBox to complement their course material. The trainees also agreed that such a manual would be invaluable for training water professionals how to use the GWP ToolBox in planning. Additional input for this manual was received from GWP Partner WaterNet, an African regional network of 72 member institutions that provides an IWRM Master's Programme across 15 states of Africa. Since its founding 20 years ago, the Programme has strengthened the water sector by delivering more than 378 Master's graduates (42 percent women) into the water field.

GWP is taking its commitment to provide knowledge-based resources one step further by collaborating with IWRM educational institutions to regularly maintain and update a Teaching Manual. The educational institutions include the German-Kazakh University serving five Central Asian countries, the University of Brasilia, Hohai University of China, and the Technological University of Panama. Five professors from varying backgrounds in fields related to water resources education were passionate about contributing their experiences of teaching IWRM for others to benefit from. Their inputs have been synthesised to create this informative Teaching Manual for lecturers and trainers of all water-related disciplines.

Authors

Dr Barbara Janusz-Pawletta holds a Ph.D. in Law from the Free University in Berlin, and in cooperation with specialists from the Free University she has built up a 2-year IWRM Master's Programme at the German-Kazakh University in Almaty. The Programme offers training for young specialists from all Central Asian countries to fill the gap between technically oriented water management programmes and programmes in other disciplines. The Programme has been announced as the UNESCO Chair in Water Management in Central Asia in 2016.

Dr Carlos Hiroo Saito has a doctorate degree in Sciences focused on Geography and Geographic Information Systems from the Fluminense Federal University in Brazil, with a background in education and biology. At the University of Brasilia, he teaches Environmental Education, IWRM, Sustainable Development, and Geographic Information Systems mainly at the graduate level.

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The GWP IWRM ToolBox Teaching Manual

Teaching IWRM, as opposed to other water-related academic programmes, is unique because it requires a trans-institutional and interdisciplinary consciousness. This manual is to help educators designing and executing IWRM courses to incorporate as many IWRM disciplines as they feel is appropriate. Throughout this manual, we hope to spread guidance and inspiration on how to incorporate IWRM thinking and useful tools and case studies into a specific course or professional workshop. Although the IWRM ToolBox is referred to extensively throughout the Teaching Manual, it does not replace it. This manual is intended to serve as supplementary material for users looking to expand use of the ToolBox within their programme or training.

The manual is comprised of four chapters. The first chapter is a compilation of lessons learned and popular teaching methods contributed by IWRM professors, based on their own experiences. This chapter serves as an introduction to the following two chapters with more detailed teaching information. Chapter 4 provides guiding questions.

The second chapter includes six key IWRM disciplines with three to four teaching subjects per discipline. These disciplines are based on common concepts involved in IWRM: The natural environment and climate, Water law and policy, Social aspects, Planning and decision-making, Economics, and Technical infrastructure. The disciplines are used to guide lecturers in finding appropriate teaching subjects for their course. For example, a lecturer of environmental studies interested in transboundary agreements would refer to the Water law and policy discipline. This section is designed to be flexible, allowing the lecturer or trainer to decide what study material they want to include in the lesson, and select the best fit subject. Below each teaching subject there will be references to useful publications, tools, and example lectures.

Chapter 3 includes all the example lectures referred to throughout Chapter 2. The lectures can be used directly, or for inspiration on how to modify and enhance a current lecture. For an easy overview, each example lecture includes (i) prerequisites, (ii) duration, (iii) content, (iv) learning objective, (v) methods used, and (vi) case studies, tools, and other related materials. Example lectures are provided in detail so that they can be directly applied to any class.

Objectives of the GWP IWRM ToolBox Teaching Manual

The objectives of this Teaching Manual are to:
- guide lecturers in incorporating the IWRM ToolBox into their courses
- inspire and unite IWRM lecturers by sharing lessons learned and useful teaching methods
- provide an overview of common IWRM disciplines and their related teaching subjects that can be integrated into a wide range of courses related to water resources
- provide ready-to-use example lectures to make integration of IWRM disciplines easier
- provide links to interactive teaching resources
- facilitate the transfer of up-to-date knowledge within the water sector.

User guide

Chapter 1. Teaching IWRM at university level
This chapter is for lecturers interested in reading about lessons learned or teaching methods contributed by current professors teaching in IWRM Master's Programmes all over the world.

Read this section if you want to:
- see what other lecturers have experienced teaching in class or designing an IWRM course
- get inspired by different teaching methods to apply in class regardless of the subject.

Chapter 2. IWRM disciplines
Here, lecturers can choose a key component from the IWRM discipline they are most interested in integrating into their curricula. Use the broad IWRM disciplines to examine components that could be added into your subject, or the discipline you are interested in expanding on within your course. Each of the six IWRM disciplines highlights three to four components that can be taught within a course, and the associated IWRM ToolBox teaching materials: publications, tools, case studies, and short video clips. Each component also refers to a teaching lecture, provided in Chapter 3.

Keywords
To get a general idea of the content of a chapter and to quickly find desired content again, the text is supplemented with keywords in the margin that highlight the content of a paragraph.

Icons
To find examples quickly, resources are highlighted with an icon and the title is hyperlinked.

Read this section if you want to:
- expand a current course with the addition of tools and case studies from the IWRM ToolBox
- assess additional IWRM components within your discipline
- gain insight into another discipline by learning about how it is linked to IWRM.

Chapter 3. Specific example lectures
For lecturers interested in lecture ideas for a course or workshop, this chapter outlines lectures and the associated material required in each. These 13 example lectures are currently applied within IWRM-related programmes from regions all over the world.

Read this section if you want to:
- broaden your teaching approach by reviewing lectures others are teaching
- gain inspiration from examples, tools, case studies, and videos
- receive guidance and share in improving lectures on IWRM
- take a lecture and apply it to your own class.

Chapter 4. Guiding questions
This chapter gives examples of guiding questions that can be used to challenge students, stimulate class discussion, or for individual study. The questions are conveniently arranged in sections based on each of the six IWRM disciplines covered in Chapter 2.

Read this section if you want to:
- find ready-to-use questions for class discussion.

The GWP IWRM ToolBox

The GWP IWRM ToolBox is a free open-access database including 62 tools complemented by reference material. The online repository of knowledge is dynamic and regularly maintained by GWP. All uploaded documents (tools, case studies, articles, briefs, reports, papers) are accessible free of charge with no need to register. The GWP IWRM ToolBox is available for anyone interested in implementing better approaches to the management of water or learning more about IWRM, not just in university education.

The GWP IWRM ToolBox is organised in a hierarchical indexed storage structure based on the three overarching pillars of IWRM, the Enabling Environment (Tools A), the Institutional Arrangements (Tools B), and the Management Instruments (Tools C).

A – ENABLING ENVIRONMENT

A1 – POLICIES
A1.01 Preparation of a National Water Resources Policy
A1.02 Policies with Relation to Water Resources
A1.03 Climate Change Adaptation Policies

A2 – LEGAL FRAMEWORKS
A2.01 Elements of Water Law
A2.02 Implementation and Enforcement
A2.03 The Role of Customary Law in IWRM
A2.04 Integrating Legal Frameworks for IWRM

A3 – INVESTMENT AND FINANCING STRUCTURES
A3.01 Investment Frameworks
A3.02 Strategic Financial Planning
A3.03 Generating Basic Revenues for Water
A3.04 Repayable Sources of Finance for Water

For readers, not familiar with the GWP IWRM ToolBox, please visit www.gwptoolbox.org

B – INSTITUTIONAL ARRANGEMENTS

B1 – REGULATION AND COMPLIANCE
B1.01 Regulatory Bodies and Enforcement Agencies
B1.02 Local Authorities
B1.03 Monitoring and Evaluation Bodies
B1.04 Impact Assessment Committees

B2 – WATER SUPPLY AND SANITATION SERVICES
B2.01 Public Sector Water Utilities
B2.02 Private Sector Water Service Providers
B2.03 Community-Based Water Supply and Management Organisations

B3 – COORDINATION AND FACILITATION
B3.01 Transboundary Organisations
B3.02 National Apex Bodies
B3.03 Civil Society Organisations
B3.04 Basin Organisations

B4 – CAPACITY BUILDING
B4.01 Information Gathering and Sharing Networks
B4.02 Training Water Professionals
B4.03 Building Partnerships
B4.04 Water Integrity and Anti-Corruption

C – MANAGEMENT INSTRUMENTS

C1 – UNDERSTANDING WATER ENDOWMENTS
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C1.02 Data Collection
C1.03 Monitoring and Evaluation Systems

C2 – ASSESSMENT INSTRUMENTS
C2.01 Risk Assessment
C2.02 Vulnerability Assessment
C2.03 Social Assessment
C2.04 Ecosystem Assessment
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C2.06 Economic Assessment

C3 – MODELLING AND DECISION-MAKING
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C3.02 Stakeholder Analysis
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C3.04 Decision Support Systems

C4 – PLANNING FOR IWRM
C4.01 National IWRM Plans
C4.02 Basin Management Plans
C4.03 Groundwater Management Plans
C4.04 Coastal Zone Management Plans
C4.05 Integrated Urban Water Management Plans
C4.06 Integrated Disaster Risk Management Plans
C4.07 National Adaptation Plans

C5 – COMMUNICATION
C5.01 Communication Channels
C5.02 Consensus Building
C5.03 Conflict Management

C6 – EFFICIENCY IN WATER MANAGEMENT
C6.01 Demand Efficiency
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C6.03 Recycle and Reuse

C7 – ECONOMIC INSTRUMENTS
C7.01 Pricing for Water and Water Services
C7.02 Water Markets
C7.03 Tradable Pollution Permits
C7.04 Pollution Charges
C7.05 Subsidies
C7.06 Payments for Environmental Services

C8 – PROMOTING SOCIAL CHANGE
C8.01 Youth Education
C8.02 Raising Public Awareness
C8.03 Water Footprint
C8.04 Virtual Water

CHAPTER 1. TEACHING IWRM AT UNIVERSITY LEVEL

Lessons learned in teaching IWRM

When teaching an interdisciplinary course that encompasses such a vast amount of information, it becomes difficult to construct the course in a way that conveys the entire concept to students. Throughout our time teaching IWRM, we have experimented with different teaching methods to improve our courses.

The following section discusses our lessons learned while teaching IWRM, as well as sharing some teaching methods in the hope of inspiring other lecturers to implement new methods or materials into their IWRM courses. It is important to recognise that IWRM is taught in degree programmes all over the world, each with their own approach to IWRM. The following tips and teaching methods should be tailored to best fit a particular course or programme.

Connecting complex linkages

One valuable lesson learned is the importance of emphasising the connection between water resources management and other sectors whenever possible (Box 1). The link connecting different sectors is usually related to water resources, as in the relation between water and land, water and climate, and water and politics. By learning about this interconnection in specific contexts, students should feel motivated to reach out to other experts for more information, whether they are professionals or indigenous people. The main goal is to promote an interdisciplinary approach to water management, and specifically water-related problems.

Box 1. Using dynamic teaching methods to illustrate IWRM. *Watershed Systems Management course, available to Master's students and senior level Bachelor students. Department of Bioresource Engineering at McGill University, Sainte Anne de Bellevue, QC, Canada.*

In Watershed Systems Management, we teach the principles and application of IWRM and adaptive management. The students apply the principles of IWRM in several ways and are exposed to the challenge of managing different interests and values. A few of our teaching methods include group projects, developing a system dynamics model, and creating a watershed management plan. In 2016, we also piloted a game that simulates a multi-stakeholder negotiation about instream flows.

One challenge is providing clear guidelines on how to apply IWRM principles in contexts that vary widely. To help overcome this, we use examples from all over the world and allow students to reflect on how they illustrate IWRM principles. It can be challenging to make the concepts relevant to all the students participating in the course, whether they be from engineering or sociology backgrounds. Through the group work, we hope students learn to negotiate between different priorities and approaches. These are skills that will help to prepare them for working in the multidisciplinary world of water.

Connecting course work to professional work

There are a few specialised MSc programmes on IWRM (e.g. WaterNet, online with MyCDnet, and ArgCapNet) offering modules that connect scientific theory with practical examples. However, in most traditional university settings, there are gaps and disconnection between different water-related disciplines. To counter this issue, a lecturer can invite specialists and practitioners to present a specific water-related topic as guest lecturers. Representatives of local or international organisations and companies provide students with concrete experiences from the water field. Not only does this shed light on the different sectors, but it also helps them connect the theoretical knowledge they are learning with a practical water-related profession. This concept can be taken a step further by planning a field trip where the students can learn about a concept in a more hands-on environment. The field trip can be enhanced if it is related to a recent case study that has been studied.

This tactic can be tied into practical field projects that students conduct jointly with their lecturers. This is applicable when teaching undergraduate students basic concepts; by maintaining a focus on national experiences, students are better able to understand concepts. Previously, the Southern African programme of WaterNet relied heavily on expertise from outside the region; now all capacity development is done within a regional or local context. This approach brings technical concepts to life as the cases provide students with insight into the realities of their country in terms of IWRM. Students will show more interest and motivation in their studies when they can see that the concepts they are learning now are important for their future careers.

Networking and providing relevant thesis opportunities

It is important for universities to have a strong network to support the regional scientific community by developing scientific research throughout the region. Through this network, students will be provided the opportunity to complete a thesis or research project in cooperation with organisations or businesses in the water sector. Students will gain an added sense of value and achievement knowing the time and effort they dedicate to their thesis is not only for themselves, but applicable to the work being done in their region. Universities may receive positive recognition from collaborators who benefit from students completing master's theses for their organisation. For example, Hohai University in China collaborates with six top national research centres and several laboratories where students are directly involved in the research projects.

Additional benefits of collaboration between universities and the community include large events that unite people from all over a region, such as a water forum. For example, the German-Kazakh University has been organising an annual water forum in collaboration with the Ministry of Foreign Affairs of Kazakhstan since 2014. A forum is a great way to create a platform for representatives of governments, universities, society, and industry to engage in joint discussions about sustainable and effective management of water resources.

There are many ways universities can circulate knowledge and experiences with other universities or professionals in the field. One way is by creating an e-journal for a particular region. For example, *Central Asia Journal of Water Resources* is a bilingual (Russian–English), open-access, peer-reviewed e-journal dedicated to all aspects of water management in the region of Central Asia. This online-based journal publishes biannually and seeks to share research and achievements of scientists from the Central Asian region and surrounding areas working in IWRM fields.

Consider students' backgrounds

Engineering students learning from a curriculum too focused on technical aspects and cost–benefit analyses may lack understanding of a project's broader context, including its historical, cultural, and socio-economic impacts. The problem can be further exaggerated when a professor's background is also of a technical nature. Professors of IWRM courses should be mindful to show how problems can be analysed from multiple points of view, and how problem solving goes beyond assessing the technical issues. Supporting these lectures by including segments on the importance of negotiation, alliances, and communication is valuable for working with others in a team.

This problem is not exclusive to engineering programmes, but can arise in all specialty programmes. It is also important to consider the anticipated role the students participating in a particular programme will play in the future. For example, it may be more important for pre-law students to understand how laws and regulations are applied and what counts as evidence, rather than focusing solely on international laws, agreements, and instruments.

IWRM as a standalone course

Experience has shown that IWRM is best approached as a standalone course. When it is included within other courses such as agriculture or forestry, a deceptive and incomplete view of IWRM can be depicted that confuses students. Although this should not deter lecturers from introducing IWRM into those courses to illustrate the interconnection between water management and other sectors, it reinforces the philosophy that IWRM should have its own course.

Different teaching methods in IWRM

In this section, several teaching methods are described that have proved successful within IWRM education based on experiences from several universities practising IWRM courses.

Lecture on terms and concepts

The GWP IWRM ToolBox is an excellent tool to familiarise students with the terms and concepts of IWRM (Box 2). The lecturer reviews the different tools combined with examples from a familiar region or alternatively a case study. An overview of a tool explained by the lecturer aims to help the student grasp the basic concept and understand what the tool means in theoretical terms. Then, the basic concept is illustrated with some examples related to the student's particular country. Another example is the use of online PowerPoint presentations and videos. For example, the use of multimedia platforms has led to the development of the IWRM online course accessible here: http://www.iwrm-education.de/#!start (Box 3).

Box 2. Using the IWRM ToolBox

Using the case study, 'The management of the Panama Canal watershed,' the author mentions 'traditional centralised approaches' and 'limited public consultation' as examples of political–cultural aspects that inhibited the implementation of IWRM. As this case was written during the first years of the twenty-first century, a lecturer can facilitate a discussion about how these aspects have evolved. Such discussions about the pertinence of the case's conclusions become a great learning tool, and an opportunity for students to read an up-to-date bibliography about the particular case study.

Box 3. Online IWRM education

The International Water Research Alliance Saxony (IWAS), together with the German International Hydrological Programme of UNESCO (IHP) and Hydrology and Water Resources Programme of WMO (HWRP), has developed an e-learning module on IWRM that is designed to complement classical learning options. Online presentations are grouped in thematic and geographical settings. In addition, each presentation allows links to be made to other presentations. This linking is very useful, as no lecturers could cover all of the issues in IWRM. Thus, by using an IT setting, a presentation being played online can be stopped and links followed to detailed explanations of terms, concepts, or additional presentations. The course can be found here: http://www.iwrm-education.de/#!start

Case method and case study method

A common method in studying legal aspects of IWRM is to focus on previous case law to illuminate the current state of law. Using this method, a lecturer refers to a court decision, international or national, that illustrates legal regulations such as principles and instruments. Students should then carry out a discussion that analyses the legal problem after it has been resolved.

This method can be modified by using a narrative, instead of a court decision, based on actual events. Narratives can be formulated using issues presented in the ToolBox case studies. Narratives should illustrate legal regulations, such as principles and instruments, which should be debated by students. The objective is to teach students how to analyse legal problems as cases develop.

A similar method is the case study method, which can be applied to wide range of environmental issues. The objective is to learn how to analyse these problems as they unfold. The example lecture 'How wolves change rivers' is an example of a case study (Yellowstone National Park, USA) used to inspire the search for the interconnections between biological and physical compounds of an ecosystem, including rivers.

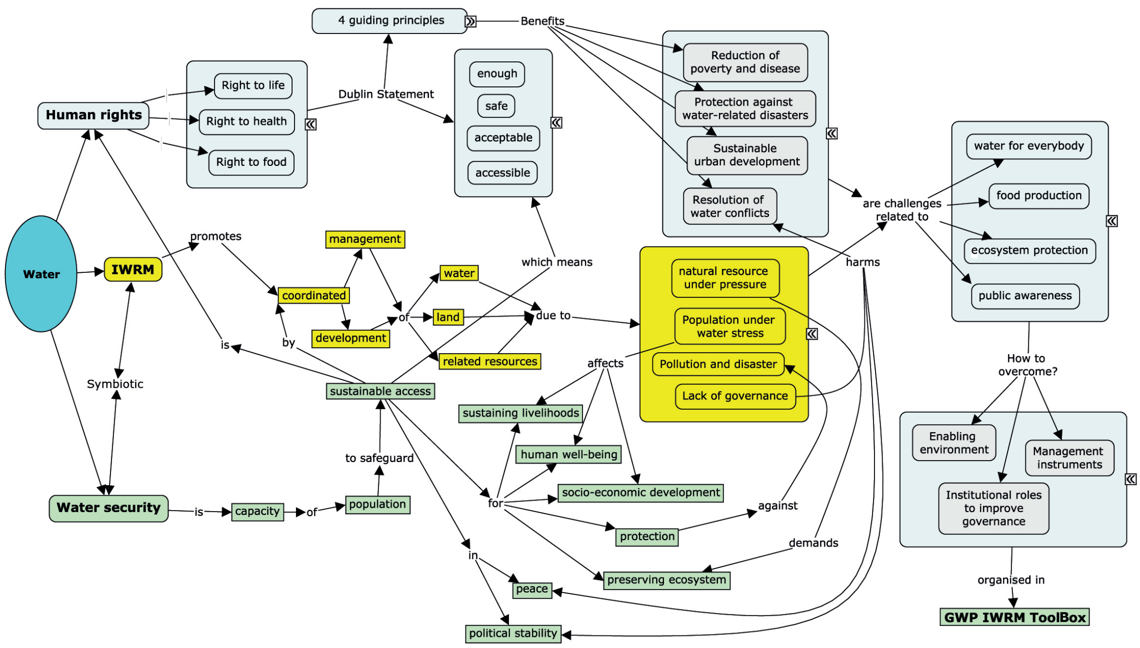
Concept maps

Concept maps are diagrams used for organising and representing knowledge, where concepts are usually enclosed in circles and arrows are drawn to show the connections among them (Fig. 1). To foster a more integrative view of water resources management, and the IWRM concept itself, the students can be asked to connect concepts on topics of water resources management, such as participation processes, disaster resilience, transboundary water management, and the priority issues of GWP, transversally crossed by gender or youth participation. The students have to construct their own concept maps and explain them in a presentation.

Students usually feel insecure developing their own concept maps because they have never done it before. To minimise this insecurity, students should be required to prepare a preliminary concept map in the middle of the course, only making connections among IWRM, water security, and the human right to water. Within their concept maps, students choose one priority issue, one cross-cutting issue, and include one case study from the IWRM ToolBox. There are many different approaches students can take when creating their maps, resulting in a very broad and rich view of IWRM.

Throughout the experience of teaching classes on IWRM in the University of Brazil, it was found that students have difficulty extracting key concepts from texts. They have to go back to the texts and read them twice or three times more, and that has very positive consequences for their apprenticeship. They also need to clarify their own ideas before explaining their concept map to the other students. The concept map is used to help students better understand IWRM, by allowing them to visualise and manipulate the concepts and processes that were described in the text.

Figure 1. Example of a concept map



Socratic method

One way to facilitate a theoretical lecture is by using the Socratic method. It is essentially a dialogue of questions and answers to help students develop their reasoning skills. The teacher first introduces a subject or particular setting. Then the teacher asks a question and selects a student to answer it and continues asking additional questions to that student or moves on to another. The questioning continues until contradiction becomes obvious and fallacy of the initial assumption is exposed.

Group work and presentation

Another technique valuable for students involves presentations of different known IWRM cases in the region or case studies from the IWRM ToolBox (Box 4). Small groups of students work on a case study, read it, and gain an understanding of its concepts and implementation. They then prepare a presentation, which they show to the class. The presentation finishes with challenging questions that the students have prepared in advance. Students then analyse the case study guided by these questions. When the students themselves prepare questions to be debated, they become co-responsible for the execution of the course, and are exposed to a diversity of perspectives instead of only one teacher's point of view on the case studies. This approach combines theoretical knowledge with concrete examples from the field. Some recent good practices show the power of using serious games and role play games that require intensive group work.

Box 4. Learning by doing in Integrated Watershed Management at Makerere University, Uganda

The idea is to learn from the community. In this course, the professor is not the teacher, but instead students are learning by working together with their classmates to address water problems with the help of community members. Students begin the course by studying maps to learn about the water resources of their area. With the help of the maps, students attempt to identify potential water resource problems, ranging from pollution and soil degradation to water scarcity. The students then travel to the field, where they observe and talk with people living in the area to determine if there are problems in these areas, and if there are any other problems. In addition to developing solutions, students are able to gain insight into the traditional practices of local communities on how they manage their natural resources. By the end of the course, students may even take on the role of the teacher by helping the community prevent further problems in the future. This method has been coined the community-based learning approach.

Students may work together to examine a basin similar to the one presented in the case and make an analysis of what is missing that would produce the results obtained in the original case.

In addition to these teaching methods, other well-known methods are recommended in any kind of course. They include, among others, the invitation of practitioners as guest lecturers, excursions and field work, laboratory work, presentations, and discussions and group work among the students.

CHAPTER 2. IWRM DISCIPLINES

1. The natural environment and climate

The natural environment and climate is a broad discipline encompassing the components of the hydrological cycle, climate change and IWRM, and ecosystems. By reading the components in this discipline, you should develop a clear understanding of the environment as possessing regularities, laws, and predictable systemic behaviour supported by science.

The water cycle in nature is continuous, moving from one phase to another (land surface to atmosphere to surface). The speed, direction, and amount of water moving throughout the cycle requires varying levels of heat, energy, and other chemical compounds to be transported in this process. It is important to be aware of changes to the water cycle influenced by climate characteristics that may result in changes to regular water patterns. The role water plays in the ecosystem's structure and dynamics shows the interdependence between physical aspects and biological aspects, with both aspects imperative to sustain life. Knowledge of the water cycle within a particular region is crucial information for any person working in a field that requires water use or the development of water management plans.

Hydrological cycle

complex system

The hydrological system generates water for all economic and social needs. As water managers, or those within sectors related to water resources, it is important to be familiar with the hydrological cycle, a complex system where several processes are interconnected and interdependent, including evaporation, condensation, precipitation, and transpiration. The balance of water that remains on the earth's surface is run-off, which empties into lakes, rivers, and streams and is carried back to the oceans, where the cycle begins again. The hydrological system is the source of all water.

water storage

There are three basic locations of water storage that occur in the planetary water cycle. Water is stored in the atmosphere, on the surface of the earth, and under the ground. Water stored in the atmosphere can be moved relatively quickly from one part of the planet to another. The types of storage that occur on the land surface and under the ground largely depend on geological features related to the type of soil and rock present at the storage locations. Storage occurs as surface storage in oceans, lakes, reservoirs, and glaciers; underground storage occurs in the soil, in aquifers, and in the crevices of rock formations.

three different types of water

It is useful to distinguish three different types of water depending on their occurrence in the water cycle[1]:

- 'white' water: rainfall and the fraction of rainfall that is intercepted and immediately evaporates back into the atmosphere, as well as non-productive open water and soil evaporation
- 'green' water: soil moisture in the unsaturated soil layer, stemming directly from rainfall, that is transpired by vegetation
- 'blue' water: water involved in the run-off (sub-)cycle, consisting of surface water and groundwater (below the unsaturated zone).

[1] Falkenmark, M. (1995) Coping with water scarcity under rapid population growth. Paper presented at the Conference of SADC Water Ministers. Pretoria, 23–24 November 1995.

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There is no green water without blue water. Blue water is the sum of the water that recharges the groundwater and the water that runs off over the surface. Blue water occurs as renewable groundwater in aquifers and as surface water in water bodies.

IWRM and the hydrological cycle

IWRM approaches management by taking into consideration the entire hydrological cycle. As humans, we can significantly impact parts of the hydrological cycle through our development, mainly by contributing to the expansion of urban settlements and agriculture. It is common for construction processes to alter natural run-off patterns by storing water or moving water (i.e. inter-basin transfers). Other construction and farming practices may also severely alter the hydrological cycle through changes in infiltration, run-off, and evapotranspiration rates, if not managed properly. It is the duty of IWRM practitioners to practise a holistic management approach, in accordance with the Dublin Principles, to ensure the sustainability and integrity of our water resources. This may include comparing the spatial (downstream impacts) and temporal (long-term sustainability) dimensions. It is the goal of IWRM to promote the interests of water users in different sectors of society (or an entire region), while provisioning for stability within the water cycle.

The following are four dimensions that IWRM takes into account[2]:

- the water resources, taking the entire hydrological cycle into account
- the water users, all sector interests and stakeholders
- the spatial dimension (distribution of water resources and uses in terms of space and scale)
- the temporal dimension (temporal variation in availability of and demand for water resources).

Useful resources

Publications

GWP (2003) Water Management and Eco Systems: Living with Change, Background Paper No. 9
GWP (2009) Water Management, Water Security and Climate Change Adaptation: Early Impacts and Essential Responses, Background Paper No. 14

Tools

Data collection (C1.02)
Geographic information system (C3.01)

Case studies

Spain: Improvement of the ecological status of the River Órbigo, León, Duero Basin (#468)
China: Integrated ecosystem management in Upper Yangtze River Basin (#406)
Armenia: State Water Cadastre of Armenia (#309)
Tanzania: Critical analysis of river basin management in the Great Ruaha (#121)
India: Andhra Pradesh Farmer Managed Groundwater System; demand side groundwater management (#388)

[2] Savenije, H.H.G. and van der Zaag, P. (2000) Conceptual framework for the management of shared river basins with special reference to the SADC and EU. *Water Policy* **2** (1–2): 9–45.

Example lectures
Hydrology and IWRM
3D model of a water basin

Videos
How Rivers Work: The Role of Groundwater (2006) UK Groundwater Forum
The Hydrological Cycle (2012)
The Impacts of Climate Change (2013)
Climate Change with Bill Nye, National Geographic (2015)

Climate change and IWRM

Climate change has long since ceased to be a scientific curiosity, and is now the major, overriding environmental challenge facing decision-makers, planners, and regulators of our time. Many factors, both natural and human-influenced, are causing changes to the earth's energy balance, including:

- variations in the sun's energy reaching the earth
- changes in the reflectivity of earth's atmosphere and surface
- changes in the greenhouse effect, which affects the amount of heat retained by earth's atmosphere.

Water is the primary medium through which these climate impacts are felt. As additional stress is placed on the global water cycle due to climate change, the frequency of water-related hazards (i.e. floods and droughts) will increase. Floods and droughts have major impacts on farm yields and national harvests, which reduce household and national food availability and agricultural income derived from crop sales, drastically hurting a nation's economy. Floods and droughts can also be extremely dangerous, threatening the health and safety of a nation's people.

The IWRM approach to addressing climate change

In order to cope with a changing climate and its potential impacts on all aspects of water management, IWRM follows a holistic approach to developing adaptation plans or strategies. The impacts of climate change are cross-cutting and therefore are most effectively managed through an integrated approach. Fragmented planning is likely to lead to unanticipated consequences (e.g. improved urban drainage to cope with increased flooding can lead to riverbank erosion, increased flood risk downstream, and reduced groundwater recharge). Creating IWRM adaptation plans is a process that begins with assessing the signs of climate change, such as floods and droughts, and their impacts on water quality and quantity to determine if there is a need for action. Adaptation plans also aim to help communities and ecosystems coping with changing rainfall patterns and other extreme weather events.

adaptation plans

Key concepts to mitigate climate change through an IWRM approach include:

- understanding the dynamics of current variability and future climate change as they affect water supply and demand across all water-using sectors; it is necessary to utilise robust institutions that can enhance the capacities of countries to respond to these dynamics
- limiting water's destructive potential by reducing the risk of water-related shocks and damage and increasing the reliability of water services for production
- implementing an effective adaptation plan to combat possible disasters such as floods and droughts that threaten lives and national development

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- using participatory planning methods to carry out vulnerability assessments to determine where the greatest risks lie under different climate scenarios.

Useful resources

Publications

GWP and INBO (2015) Water and Climate Change Adaptation in Transboundary Basins: Lessons Learned and Good Practices, Handbook No. 4
GWP (2009) Water Management, Water Security and Climate Change Adaptation: Early Impacts and Essential Responses, Background Paper No. 14
GWP (2007) Climate Change Adaptation and IWRM – An Initial Overview, Policy Brief No. 5
GWP and WMO (2009) Flood Management in a Changing Climate, A Tool for Integrated Flood Management
Cap-Net UNDP (2009) IWRM as a Tool for Adaptation to Climate Change

Tools

Climate change adaptation policies (A1.03)
Data collection (C1.02)
Monitoring and evaluation systems (C1.03)
Integrated disaster risk management plans (C4.06)
National adaptation plans (C4.07)

Case studies

Transboundary Honduras: Early warning system of La Masica Municipality (#392)
Adaptation to climate change in the countries of the Lower Mekong Basin (#385)
Nicaragua: Adaptation and vulnerability reduction to climate change in the water sector; example of wetland management (#417)

Example lecture

The economics of climate change adaptation

Videos

Caribbean Regional Framework for Investment in Water Security and Climate Resilient Development (2016) GWP Caribbean
Climate Resilience Is.... (2016) UNDP
Climate Change in the Pacific: WATER (2015) UND
Integrated Drought Management Programme in Central and Eastern Europe (2014) GWP CEE
Managing Water for Climate Resilience in Africa (2013) GWP.
Water and Climate Programme in Central America (2013) GWP Central America
Voices from the Field (2016) IWMI at The WaterChannel

Ecosystems

Water management assesses human-induced impacts on water bodies in terms of hydrological aspects. However, water sustains life not only in its terrestrial forms, including human beings, but also within water bodies. Aquatic biodiversity can be heavily impacted by structural interventions to an ecosystem. Therefore, it is critical to maintain water bodies because of their role in regulating ecosystems. Humans rely on ecosystems for the provision of clean drinking water and the putrefaction of waste, and would be unable to survive without these services. The services ecosystems provide, including provision of food and water, regulation of climate

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and disease, support of the global hydrological cycle and nutrient cycles, and cultural and recreational benefits are called ecosystem services.

ecosystem services

Water mediates all these services by sustaining the ecosystems in our cities and throughout the world. The land management decisions made at different scales, from local interventions by individual households, farmers, and industries to those made at a catchment level by rural and urban planners and communities can impact the health of our ecosystems. Aquatic ecosystems are among the world's most complex and biologically diverse, and scientists are still discovering the magnitude of the interdependencies of ecosystem properties. A few examples of these interdependencies are:

- the interdependence between water and biodiversity
- the role of water in sustaining biodiversity
- the role of biodiversity in sustaining water sources
- broad concepts such as flow, storage, source, sink, corridor, barrier, trophic cascade, endemism, resilience, dynamic stability.

The IWRM approach to ecosystem management

It is important for those engaged in IWRM to have sufficient understanding of the value of ecosystem services to determine the true economic and social costs of planned interventions. This applies to both water services solutions (e.g. water supply abstraction/storage, wastewater discharge) and other sectors that impact the water cycle (e.g. housing, transport, industry, agriculture). Due to the lack of knowledge on how ecosystems produce ecosystem services, urban planners, water managers, and farmers should work together to thoroughly evaluate the future implications of disrupting and modifying ecosystems.

Useful resources

Publications

GWP and INBO (2015) The Handbook for Management and Restoration of Aquatic Ecosystems in River and Lake Basins

GWP (2016) Linking Ecosystem Services and Water Security, Perspectives Paper No. 9

Tools

Ecosystem assessment (C2.04)

Environmental impact assessment (C2.05)

Raising public awareness (C8.02)

Case studies

Slovenia: Ecosystem restoration of Lake Cerknica (#448)

Spain: Improvement of the ecological status of the River Órbigo, León, Duero Basin (#468)

Kenya: Challenges facing the implementation of IWRM in Lake Jipe Watershed (#479)

Barbados: Collaboration and enforcement – the missing pieces of the puzzle in managing the Graeme Hall Swamp (#477)

Austria: Restoration of Mur River: ecological values and hydropower generation aligned (#456)

Example lectures

Water conservation

How wolves change rivers

Videos
How wolves change rivers (2014)
Carbon map: http://www.carbonmap.org/
Webinar: Squeeze an orange, but don't squeeze the deltas please! (2015) Delta-Alliance at the WaterChannel

2. Water law and policy

IWRM offers an important contribution to strengthening the legal framework for national and transboundary water management, as well as presenting an effective approach to designing water policy and institutional frameworks. All these three – law, policy, and institutions – are inherent components of the concept of water governance, which according to the GWP is "… the range of political, social, economic, and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society".[3]

The key aspects of IWRM as discussed throughout this manual require a sound legal framework on both international and national levels, policy directions for functioning and further development, and a supportive institutional organisation structure. The international and national systems of laws determine the scope of states' rights and obligations with regard to watercourses, for purposes other than navigation. They cover water ownership, development, and management. A legally embedded system of water management is based on water policies developed on national and international levels. The water management institutions, both interstate and national, put into operation the integrated approach to water management, and are therefore regarded as one of the most essential components of water management.

Water law and policy and IWRM

The third United Nations World Water Development Report[4] indicated water crises are a result of the mismanagement of water resources at the local, national, and international levels. This report points out the necessity of interdependence between water governance and (integrated) water resource management. Water law and policy set relevant frameworks for both concepts. IWRM can be viewed as an essential tool to achieve (good) water governance, as long as there is a reliable law, a well-established political system in place, and a network of institutional arrangements. The IWRM approach relies on an existing legal and policy framework to implement IWRM's core principles, including participation and decentralisation, to be facilitated by institutions. IWRM offers a set of instruments to facilitate optimal water resources management, and promotes a strong, normative framework, which can be implemented in the context of well-functioning overall state governance. A major role of the water sector involves developing normative policy frameworks that meet the existing international standards. States are recommended to meet international policy standards and legal regulations and implement them within their national systems.

[3] GWP (2003) Effective Water Governance, Background Paper No.7, p.9.
[4] UNESCO (2009) World Water Assessment Programme. 2009. The United Nations World Water Development Report 3: Water in a Changing World. UNESCO, Paris and Earthscan, London.

Applying IWRM principles to strengthen transboundary water management through legal frameworks

international water law

Hydrological boundaries do not match national borders. Hence sustainable water management through a basin/watershed approach is only possible through cross-border collaboration and interstate agreements. International water law is an essential means of achieving this. In regulating transboundary watercourses, three most important issues must be covered: water ownership, development, and management. In terms of water ownership, the state possesses all natural resources within its territory; however, its sovereignty is not unlimited. Water management covers water development, use, protection, allocation, regulation, and control. International water law is based mainly on two sources that are applicable worldwide, the UN Convention on the Law of Non-navigational Uses of International Watercourses (1997), and the United Nations Economic Commission for Europe (UNECE) Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1992), as well as a number of multilateral regional and bilateral agreements on separate watercourses around the world. International law has rarely taken groundwater into account. While surface water treaties abound, groundwater is nominally included unless it relates to surface waters. Few legal instruments contain groundwater-specific provisions, and even fewer address groundwater exclusively.

Management of transboundary watercourses requires the application of fundamental precepts of international water law. The principle of equitable and reasonable utilisation of waters, the principle of no significant harm, and the principle of cooperation outline the general guidelines for determining the scope of states' rights and obligations for purposes other than navigation in respect to international watercourses. First, equal rights for a state to utilise an international watercourse does not mean equal sharing of a particular watercourse by all riparian states. Second, reasonable use of waters does not equal the most productive use or application based on the most efficient methods, but is defined in recognised international water policy instruments. Third, countries shall take appropriate measures to minimise environmental harm within their state and across boundaries. States are under an obligation to take all appropriate measures to ensure that activities conducted under their jurisdiction do not cause significant harm to or within the territory of other state(s).

A prerequisite for implementing international water law principles is the states' obligation to cooperate. States may cooperate through use of various instruments, especially for information exchange and consultation meetings. Prior notification of planned activities that could cause significant transboundary harm (i.e. environmental impact assessment), is required by states, regardless of whether watercourse states have concluded any specific agreement on the issue.

International law sources envision five core elements of effective transboundary watercourse regimes:

- geographical and functional scope of transboundary water resources
- principles (substantive rules) for equitable and reasonable use, avoiding significant harm, which are put into operation using the principle of cooperation
- procedural rules prescribing mechanisms for information exchange, consultation meetings, and environmental impact assessments
- management of transboundary water resources in an integrated way using institutional mechanisms that facilitate interstate water cooperation among riparian states
- employment of rules and procedures governing dispute settlements among riparian states.

Useful resources

Publications
GWP (2015) Promoting Effective Water Management Cooperation among Riparian Nations, Background Paper No. 21
GWP (2013) International Law – Facilitating Transboundary Water Cooperation, Background Paper No. 17
GWP and INBO (2012) A Handbook for Integrated Water Resources Management in Transboundary Basins of Rivers, Lakes and Aquifers, Handbook No. 2
AGW-Net, BGR, IWMI, Cap-Net, ANBO and IGRAC (2015) Integration of Groundwater Management into Transboundary Basin Organizations in Africa – a Training Manual
LA-WETnet, Cap-Net UNDP and GWP (2015) *Derecho Internacional de Aguas en América Latina, Manual de capacitación* [in Spanish]

Tools
Legal Framework (A2)
Regulatory bodies and enforcement agencies (B1.01)
Transboundary organisations (B3.01)
Basin organisations (B3.04)
Conflict management (C5.03)

Case studies
Transboundary: The Drin Coordinated Action; Towards an Integrated Transboundary Water Resources Management (#459)
Lao PDR: Water Planning and Economic Development (#408)
Transboundary: Groundwater management issues for Guarani aquifer (#368)

Example lectures
Institutional cooperation on transboundary watercourses
Role play game – hypothetical situation of a shared river

Video
Trailer: Bridging Waters (2010) SADC

Applying IWRM principles to strengthen the legal framework for national water management

water use rights

The international water law, and any agreement specifically referring to a watercourse, is usually implemented by actions at the national level, where most water management efforts take place. National law offers a framework for allocation of water use rights, both for consumptive (including permanent removal of water) and non-consumptive (including temporary removal of water from the water system, authority to pollute, or right to impound water) purposes. It regulates management of ground and surface waters, as well as related natural resources, predominantly related to land use for agriculture and forestry. Any use of resources that may adversely affect water quality requires adequate regulation, such as the control of diffuse pollution sources. National law also addresses the provision of water services for domestic and other purposes, such as irrigation.

The question of ownership rights over water resources is related to, but not synonymous with, user rights. It is also closely connected to the question of access. In current national water law systems, water is owned by the state (or by the population as a whole). Cases of private water ownership are limited and linked to land ownership, where it is difficult to separate the rights of ownership over land from the rights of use and ownership of water. Individuals may own water, but with restricted rights to the use of that water. With regard to the management of a water resource, the location can have major implications for, and lead to potential restrictions on, the rights of use, which can in turn impact the availability of water resources in a transboundary context. Every state has its own set of rules for allocating water use rights, often comprised of different systems resulting from local history, existing customary legal systems, and the level of economic development of the state. Commonly, water use rights can be acquired in the following ways:

- rights derived from land ownership
- established use including customary and prescriptive
- rights of free use (where certain minimal levels of water use do not require authorisation)
- administrative permits or authorisations (where licences/authorisations specify amount/location/duration/holder of the right and usually cover large-scale abstractions for agricultural, industrial, or municipal use).

National law provides and secures proper implementation and enforcement of water management principles. There are also many other areas of law not directly addressing water issues that nevertheless affect management of the water environment. These include land use planning, environmental assessment, nature conservation, and environmental law. Public health laws influence the supply of water and sanitation, as does land tenure reform. The IWRM approach emphasises institutional cooperation on each level, involving all stakeholders: government officials, local authorities, civil society groups, the private sector, and community organisations. Institutional cooperation foresees, among other achievements, the setting up of apex bodies, the creation of river basin organisations, and the strengthening of regulatory and enforcement agencies. Finally, national law enhances water management by providing rules for the resolution of possible conflicts among competing uses of the water resources.

Useful resources

Publications

GWP (2003) Effective Water Governance, Background Paper No. 7
GWP (2004) Catalyzing Change: Handbook for Developing IWRM and Water Efficiency Strategies

Tools

Legal Frameworks (A2)
Regulation and Compliance (B1)

Case studies

Sri Lanka: Swings and roundabouts; A narrative on water policy development (#350)

Video

Institute of Water Policy Corporate Video (2010) National University of Singapore

Incorporating an IWRM approach into water policy

Water policy sets the objectives and framework for the management of water resources. IWRM calls for the water policy to encompass national sector policies. These policies provide the framework for the development and management of water resources and all their competing uses such as sanitation, irrigation, hydropower development, and environmental needs, as well as the intrinsic services that water provides. Water policy is used to address conflicts that may arise from these competing uses of water, on both the national and international levels, in order to provide for water security. Defined by the United Nations, water security is "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability".[5]

water security

Access to water is unequal, and the scarcity of water compared to other goods poses the question of its value. How a society views and classifies water, whether as a social and public good or economic commodity, affects how it is addressed in water policy. One approach classifies water as a social good, due to its value for life, health, and the cultural dimension. The recognition of water as a social good has been translated into a UN resolution as one of the fundamental human rights. Another classification values water as an economic commodity, allowing for economic principles and instruments to regulate its management. The last classification option is to determine if water is a public or private good, or both.

If water is recognised as a public good, then water availability will be used to benefit society. When water is recognised as a private good, its consumption/use by one user impacts consumption/use by others. Water production and allocation become dependent on how much one consumer is willing to pay, ignoring the unequal distribution of income within a society. Water can be recognised as both a public and a private good depending on the circumstances and parameters within a policy. One question that arises when classifying water in water policy is how water's economic value will vary from its financial value (which is measured merely by market prices).

A few key water policy principles include the polluter pays principle, the precautionary principle, the principle of preventive action, sustainable development, sovereignty over natural resources, and the responsibility not to cause damage to the environment of other states or to areas beyond national jurisdiction, etc. These policy principles are widespread throughout international and national water legislation, and widely applied in many contexts of water management, including a number of legally non-binding international instruments of environmental policy (e.g. Stockholm Declaration of 1972, Rio Declaration on Environment and Development and Agenda 21 of 1992). The implementation of environmental policy principles relies on institutional developments to create appropriate models for water governance. There are a number of policy documents (UNDP, World Bank, Asian Development Bank, etc.) defining the key elements of good governance to be implemented on the national level. Key qualities of good water governance include: accountability, transparency, and participation. A well-functioning public sector, legal framework, and strategic policy planning amounts to 'good governance' status.

[5] UN-Water (2013) *Water Security and the Global Water Agenda: A UN-Water Analytical Brief.* UN-Water, Geneva, Switzerland.

Useful resources

Publications
GWP (2012) Social Equity: The Need for an Integrated Approach, Policy Brief
GWP (2009) Triggering Change in Water Policies, Policy Brief No. 8
GWP (2004) Catalyzing Change: Handbook for Developing IWRM and Water Efficiency Strategies

Tools
Preparation of a national water resources policy (A1.01)
Policies with relation to water resources (A1.02)

Case studies
Zambia: Integrated Water Resources Management and Water Efficiency planning process (#332)
Uganda: How effective are environmental policies in Uganda? (#397)
Cambodia: Sharing the reform process of water governance (#444)

Video
Water Policy for the People (2010) David Zetland at TEDxWageningen

Institutional arrangements for IWRM

Water institutions may be regarded as one of the most essential components of water management because they mandate the policies and governance of IWRM. The interstate institutional mechanisms set up by riparian states to facilitate interstate water cooperation are shaped by states' and regions' political and physical settings[6] as well as economic, social, and cultural traditions. Umbrella organisations for basin management, including all relevant stakeholders on all levels of governance to fulfil goals, are statutory decision-making and/or advisory bodies, management bodies, development entities, and regulatory bodies. Depending on the statutory agreement, institutions can extend their authority over entire watercourse basins, transboundary waters, other waters (such as multiple basins) shared by basin states, or a particular project, programme, or use of a watercourse. It is common for institutions to work as joint commissions (e.g. river basin commissions), consisting of a group of state-appointed officials, supported by full-time staff and a technical office to monitor and regulate management of a transboundary watercourse. There is no general legal obligation for basin states to enter transboundary institutional cooperation. However, it is a common practice to establish such arrangements, often viewed as a precondition of effective implementation of basic water law principles.

On the national level, IWRM demands a considerable degree of coordination among management authorities. A high complexity of water resource management may lead to institutional fragmentation as different organisations are mandated to address particular parts in isolation. The water resource authorities exist on different levels: national, basin, and local. It should also be noted that many decisions relevant for water management (e.g. on water allocation) are made by non-water bodies (e.g. municipalities). The national water authorities may take the form of a separate ministry or sit within a sector ministry responsible for either environmental aspects or for the main water user, e.g. agriculture, energy, forestry, etc.

[6] German Foundation for International Development (1998) *Berlin Recommendations: Lessons Learned, Challenges and Issues for the Future.*

Relations between national agencies and authorities and regulatory or enforcement agencies within the water sector may be strained as a result of:

- controlling water quantity and quality in surface waters, which involves managing water resources across many use sectors, and the water authority may be a part of the broader sector ministry responsible for the main water users, normally agriculture
- division between management of surface and groundwater, which may lead to overuse
- flood management and relevant research, planning, and infrastructural development.

In federal states, assignment of institutional responsibility from national to state level often leads to misalignments in the international context. In some cases, special efforts may be devoted to establishing cross-sector policies dedicated to a particular problem – like disaster management. Such institutions do not necessarily receive the status of a responsible authority, but may be assembled within the umbrella bodies with membership reflecting the interests of relevant authorities (apex bodies). At basin level, management institutions and river basin organisations provide the appropriate level of coordination between water and land use for better implementation of the IWRM approach.

Useful resources

Publications

GWP and INBO (2009) A Handbook for Integrated Water Resources Management in Basins, Handbook No. 1
GWP (1999) The Dublin Principles for Water as Reflected in a Comparative Assessment of Institutional and Legal Arrangements for IWRM, Background Paper No. 3
GWP (2016) Increasing Water Security: The Key to Implementing the Sustainable Development Goals, Background Paper No. 22

Tools

Regulation and Compliance (B1)
Basin organisations (B3.04)

Case studies

Cambodia: Sharing the reform process of water governance (#444)
Jordan: From water service provision to planning and management in the Jordan valley authority (#161)
Transboundary: Junction of land degradation, biodiversity loss and water resources management in Kagera and Nyando catchments of Lake Victoria basin (#384)
Brazil: Progress towards the integration of water resources management (#289)
Australia: The Murray-Darling Basin Commission (#25)
Cameroon: Challenges in Kumbo community to improve water supply management (#364)
Kazakhstan: Institutional reform in water sector to implement IWRM plan (#342)

Video

Key insights on IWRM planning from 13 countries (2010) GWP

3. Social aspects

IWRM requires understanding not only the technical aspects of management, but also the social aspects related to water security. Human health and well-being correlates with the availability of clean water resources. Increasing access to water for health benefits is a core interest in the global agenda incorporated in the Sustainable Development Goals. Water and human well-being goes beyond improving human physical health: it also contributes to human psychological health. Being able to identify the spiritual value of water to indigenous people and the importance of water for their culture and traditions is an important component of assessing psychological health. One reason conflicts related to water access occur is a misunderstanding about how other people value water. By listening to local people, respecting cultural diversity, and considering gender inequalities, conflicts can be avoided. The best way to facilitate this type of environment when managing water resources is by following a participatory water management process.

Water and health

health impact assessment

The IWRM approach also addresses health issues related to water resources development. The integrated approach provides a powerful tool to design water management interventions for priority health issues. Health impact assessment is a key decision-making tool in the planning of IWRM. Mitigating measures and health safeguards will form the basis for a sustainable public health approach that will prevent the transfer of 'hidden costs' to the health sector and allow the health services to adapt to new needs as they arise with the development of water resources. The economics of IWRM, health status, and health services are intricately linked.

water safety planning

Adequate water, sanitation, and hygiene (WASH) are essential components of providing basic health services. Although drinking water in many countries is pre-treated before it is supplied to homes, treatment costs can be reduced and the risks to public health can be limited by taking extra precautions to protect source water from contamination. Protecting surface water from contamination requires a structured approach to understanding surface waters and their catchments to support the identification, assessment, and prioritisation of the risks. Groundwater often requires little or no treatment to be suitable for drinking. However, groundwater may become rapidly contaminated if protective measures at the point of abstraction are not implemented and well maintained. It is also necessary to understand the limitations of a wastewater treatment system, for example being aware that some substances (e.g. hormones) cannot be removed. Having a structured approach helps in the development of management strategies for risk control and the basis for providing safe drinking water. Water safety planning is managing water supply in an organised way. Water safety plans require a risk assessment including all steps in water supply from catchment to consumer, followed by implementation and monitoring of risk management control measures, with a focus on high priority risks.

Preserving the quality of fresh water is important for drinking water supply, food production, and recreational water use. Water quality can be compromised by the presence of infectious agents, toxic chemicals, and radiological hazards. These toxins bio-accumulate in animals, and are generally passed up the food chain. Humans can become ill from exposure to heavy metals not by directly drinking contaminated water, but by consuming fish that can bio-accumulate these toxins. Water safety and quality are fundamental to human development and well-being. Providing access to safe water is one of the most effective instruments in promoting health and

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reducing poverty, with 'safe' referring to water that does not contain harmful microorganisms or any other substances that may make people sick.

Useful resources

Publications

GWP (2015) Forecasts of Mortality and Economic Losses from Poor Water and Sanitation in sub-Saharan Africa, Technical Focus Paper No. 9
GWP (2014) Water Security: Putting the Concept into Practice, Background Paper No. 20

Tools

Social assessment (C2.03)
Raising public awareness (C8.02)

Case studies

Haiti: The Impacts of the 2010 Earthquake on Water and Sanitation in Port-au-Prince (#469)
Romania: Lessons from Water Safety Plans for small-scale water supply systems as developed by schools (#427)
India: A campaign for conservation of water bodies by water user groups (#246)
Cameroon: Lessons from domestic rain water harvesting (#460)

Videos

Managing Water to Adapt to Climate Change (2009) GWP
Know Fluoride prevent Fluorosis (2016) Fluoride Knowledge and Action Network at TheWaterChannel

Cultural and spiritual aspects of water

Water has more than a health or economic value for communities. Many indigenous/first nations people have a spiritual connection to water, and water occupies a central role in their cosmology. They can also recognise interdependencies between water and local biodiversity that others cannot. Rural communities often have a strong dependency on water, and their history contributed to the emergence of knowledge, respect for, and reverence of water. They have their own ability to find water sources and ways to protect them. Urban communities naturally develop cultural interactions with water, which can be seen in the way they build their houses: facing the water when it has aesthetic value, or alternatively backing on to water that can be ignored, is less valued, and is a repository of wastes.

When thinking about the cultural and spiritual aspects of water, we should consider:

- the role of spiritual values in the relationship between humans and water
- mainstreaming multicultural respect and valuation
- how different cultures value water
- how water usage is related to the culture and the ancestors of local people
- how technologies and different ways of land use were developed according to cultural references to water, even if this is unconscious
- how culture and spiritual values can be expressed by means of customary local laws.

Useful resources

Tools
The role of customary law in IWRM (A2.03)
Social assessment (C2.03)
Raising public awareness (C8.02)

Example lecture
Cultural heritage and spiritual aspects of water

Case studies
Kenya: Water for the Maasai (#140)
China: The Functional and Protective Mechanism of Gravity Irrigation System in Ziquejie Terrace (#483)

Videos
Roshni: An End of the Darkness (2016) Heeals at TheWaterChannel
Trailer: Yasuni Man Documentary (2016) Ryan Killackey at TheWaterChannel

Resolution of water conflicts

Disputes over water resources appear frequently on both national and international levels. Disagreements arise when a new water user or one who has increased their use acquires additional water resources, leading to inadequate availability for the needs of all users (conflict-of-use). Conflicts may also arise from national policies struggling to provide for food security or energy security. On an international level, disputes may result from diverging interpretations of existing obligations under water treaties. Conflict management is a voluntary process and, when successful, it saves time and money. However, the ultimate mechanism for conflict resolution is the law. Legal procedures, on both national and international levels, set the framework of mechanisms to settle disputes. The set of legal rules governing international disputes is well established.[7] Such mechanisms include both 'diplomatic' and 'legal' (judicial) measures.

negotiation

The most frequent means of dispute resolution is negotiation by states. Negotiations are applicable at any stage of the conflict. Other forms of dispute settlement require the involvement of a neutral third party. One example is 'good offices', where a third party (state, international organisation, an individual) offers a 'go-between' service to persuade the conflicting parties to enter into negotiations. Inquiry and fact-finding are mechanisms designed to discover the truth when facts are disputed at a technical level. Third parties can help by making recommendations and minimising the potential political tensions. Conciliation is a procedure where a third party is both examining the facts and suggesting the terms of a settlement. A more neutral involvement of a third party is used in 'mediation', where a mediator assists parties in finding a solution, without imposing their own opinions.

The 'legal', in contrast to the diplomatic, means of dispute settlement are arbitration and adjudication, both of which are obligatory for the participants. Arbitration is a more flexible mechanism, leaving the parties to use their discretion concerning the composition of the

[7] UN (2012) 'Mavrommatis Palestine Concessions.' Summaries of Judgments, Advisory Opinions and Orders of the Permanent Court of International Justice. pp. 28–37.

arbitral court and the procedures to be applied. Adjudication serves as the final available option in a water dispute, officiated by a standing judicial body, such as the International Court of Justice or national court.

Useful resources

Publications

GWP (2013) International Law – Facilitating Transboundary Water Cooperation, Background Paper No. 17
GWP (2003) Effective Water Governance, Background Paper No. 7
Cap-Net/UNDP (2008) Conflict Resolution and Negotiation Skills for Integrated Water Resources Management, Training Manual

Tools

The role of customary law in IWRM (A2.03)
Communication (C5)

Example lecture

Role play game – hypothetical situation of a shared river

Case studies

Ethiopia: Participatory IWRM planning: Lessons from Berki Catchment (#365)
India: A tale of rehabilitation of people displaced due to dam construction (#250)
Slovakia: Urbanisation and wetland restoration: Conflict or Concord? (#367)
India: Social side-effects of the Upper Veda Dam Project (#308)

Videos

Webinar: Water Rights and Water Conflicts (2016) Spate Irrigation Network Foundation at TheWaterChannel
Lands and Rights in Troubled Water (2016) De Tijger produkties at TheWaterChannel

Gender equity

The water sector has been a pioneer in understanding that the involvement of both men and women in water management is imperative to ensure development opportunities and equitable management. The central role of women in water management has been formally recognised since the International Conference on Water and the Environment in 1992 (Dublin Principle No. 3 on the role of women in water management).

Gender equity is a concept that refers to socially constructed roles, behaviour, activities, and attributes that a society considers appropriate and ascribes to men and women, and which determine how they are expected to behave, think, and act. Due to historical, economic, cultural, and religious factors, certain societies are more prone to social and gender inequity and inequality, normally biased in favour of men. In many countries, mainly developing countries, girls and women are the ones responsible for fetching and safeguarding water for household and agricultural purposes, yet men hold a majority, if not all, of the decision-making positions.

gender mainstreaming

Gender mainstreaming is “a strategy for making women’s as well as men’s concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of the policies and programmes in all political, economic and societal spheres so that women and men benefit equally and inequality is not perpetuated".[8] Mainstreaming includes gender-specific activities and positive actions, whenever women or men are in an unfavourable position. Despite high levels of awareness of the importance of gender in water resources management, 22 percent of 134 countries that participated in the 2012 UN Survey on the Application of Integrated Approaches to Water Resources Management thought that gender mainstreaming for water management was not relevant to them. Hence, it is clear that extra time, human and financial endeavours, and a strong political will are required to introduce the gender perspective in implementing integrated approaches to water resources management.

Gender equity and IWRM

Gender stereotypes concerning the abilities and interests of men and women create non-equitable decision-making. Involving both genders equally in consultation processes and in management and implementation of water-related projects results in efficient, effective, and equitable management of water resources. Thus having a gender mainstreaming approach will contribute to redressing the inequality and can impact positively on the social, political, and economic position of women. In developing countries, improved water services will give women and girls more time for productive activities such as education, empowerment activities, and leisure.

Understanding that water management and environmental sustainability in general are enhanced when the priorities and demands of all stakeholders are addressed is vital. The institutional capacity should address gender in all dimensions of water management. Training is invaluable in providing support, advice, and understanding to develop tools and policies. Policies and strategies on water management need to respect gender differences. In this sense, gender disaggregated data collection and evaluation, as well as monitoring programmes, are important in understanding differences and imbalances and in following the implementation of policies and programmes.

Useful resources

Publications
GWP (2006) Mainstreaming gender in integrated water resources management strategies and plans: practical steps for practitioners, Technical Brief No. 5

Tools
The role of customary law in IWRM (A2.03)
Social assessment (C2.03)

Case studies
Pakistan: A Successful Model of the Urban Water Partnership in Karachi (#440)
India: Women's Empowerment and Increased Food Security - an Experience from Jharkhand (#485)

Videos
Dary, Woman Champion from Cambodia (2016) Oxfam
Breaking the gender mold: voices from the field (2015) CGIAR WLE at TheWaterChannel

[8] UN Economic and Social Council (1997) *Mainstreaming a gender perspective into all policies and programmes in the United Nations System*. A report of the Secretary-General, 9 May 2013.

4. Planning and decision-making

The planning and decision-making process is part of a broader paradigm known as public policy development. In order to plan and make decisions wisely, policy-makers start by understanding the extent of current or potential environmental damage. Then, they must establish environmental quality objectives before they can begin to consider various policy options capable of achieving these objectives. The formal adoption and implementation of policies is then assigned to different actors. Finally, the policy is monitored and evaluated. In practice, many factors influence this process, ranging from national economic conditions, politics, and trade implications to public opinion. Many actors also influence the process – private industry, scientists, environmental activists, economists, and government agencies. Proposing and implementing new policies involves many key players because the actions carried out may have significant implications for the quality of life for society and for future generations.

Integrated water resources management planning

water security

IWRM involves complex planning and decision-making across different sectors in order to achieve water security. IWRM relies on key players of the varying sectors that use water resources to collaborate on management issues. It is a continuous process that results in the development of comprehensive water resource management plans, such as National IWRM Plans, Basin Management Plans, Groundwater Management Plans, Coastal Zone Management Plans, Integrated Urban Water Management Plans, Integrated Disaster Risk Management Plans, and National Adaptation Plans.

participatory process

IWRM planning considers supply and demand management planning alternatives. It includes analyses of engineering, economic, societal, and environmental costs and considerations while balancing the needs of competing users and multiple objectives for the use of the resource. It is an open and participatory process involving all stakeholders and striving for consensus, while encompassing least-cost analyses of short- and long-term planning options, and satisfying utility and regulatory policy goals. Finally, IWRM planning explicitly seeks to identify and manage risk and uncertainty and provides for coordination of planning between water and wastewater utilities in a specific region/basin.

IWRM planning emphasises options and alternatives that incorporate consideration of a community's quality of life and environmental issues. IWRM planning attempts to consider all direct and indirect costs and benefits of demand management, supply management, and supply augmentation by using alternative planning scenarios, analyses across disciplines, community involvement in the planning, decision-making, and implementation processes, and consideration of other societal and environmental benefits.

Useful resources

Publications

GWP (2000) Integrated Water Resources Management, Background Paper No. 4
GWP (2004) IWRM and Water Efficiency Plans by 2005: Why, What and How? Background Paper No. 10
GWP (2004) Catalyzing Change: Handbook for Developing IWRM and Water Efficiency Strategies

UNEP/MAP, PAP/RAC, GWP Med and UNESCO-IHP (2015) An Integrative Methodological Framework (IMF) for coastal, river basin and aquifer management. PAP/RAC, Split, Croatia
GWP (2009) Lessons from IWRM in Practice, Policy Brief No. 9
Cap-Net, UNDP and GWP (2005) IWRM Plans: Training Manual and Operational Guide
GWP (2013) The Role of Decision Support Systems and Models in Integrated River Basin Management, Technical Focus Paper No. 2

Tools
Implementation and enforcement (A2.02)
Integrating legal frameworks for IWRM (A2.04)
Repayable sources of finance for water (A3.04)
National apex bodies (B3.02)
Basin organisations (B3.04)
Understanding Water Endowments (C1)
Stakeholder analysis (C3.02)
Planning for IWRM (C4)

Case studies
Pakistan: A Successful Model of the Urban Water Partnership in Karachi (#440)
India: Conservation and management of Bhoj Wetlands (#329)
Eritrea: Vital aspects of the Eritrean IWRM planning process (#366)
Zambia: Integrated Water Resources Management and Water Efficiency planning process (#332)
Malawi: Ensuring sustainability in IWRM processes (#374)
Kazakhstan: Institutional reform in water sector to implement IWRM plan (#342)

Video
Water Cooperation for a Water Secure World (2013) GWP

Participatory processes and IWRM

What differentiates IWRM from traditional water management approaches is the meaningful involvement of stakeholders in the decision-making and implementation process. The analysis, selection, and facilitation of stakeholders are all considered as participatory processes within IWRM. Following a strategic participatory approach is the most efficient way to provide equitable access to all because it not only recognises minorities, but encourages their participation and input throughout water resource projects. The participation is not just another step in the IWRM planning process. It is highly unlikely that any plan can be implemented successfully if it does not meet with broad public acceptance and if it is not supported by key stakeholder groups.

The first step to facilitating participatory processes is to identify all potential stakeholders within a project or decision-making process. It does not mean that all stakeholders are to be involved in everything all the time. Methods suggest identifying primary and secondary stakeholders. Key stakeholders have significant influence within a project, and without their support the project may not happen. Primary stakeholders are affected either positively or negatively by the project/decision. Secondary stakeholders generally include governmental, non-governmental, and private sector institutions; however, this can vary depending on what is being consulted on. It is important to indicate which stakeholders will be beneficiaries, and which will be negatively impacted. This helps to gauge which parties will support the project as advocates, and which may impede the project, acting as opponents. Intelligent targeting of interest groups can also help to reduce the danger of 'consultation fatigue'. On the contrary, there should be tangible benefits for participants who are engaged. The last step is to determine whether there are issues of gender equality that need to be considered and evaluated, and to ensure all vulnerable groups are represented within the project.

shared vision planning

collab-orative modelling

When working with a large group of stakeholders, it is important to facilitate strong communication channels and appoint trustworthy moderators. Through these channels, moderators can encourage consensus building in order to resolve a difference of opinion, and conflict management when appropriate in order to reach a compromise between the stakeholders. One communication tool to avoid disputes over water resources is shared vision planning, which facilitates communication throughout a project or decision-making process. Shared vision planning, which has recently evolved into collaborative modelling, combines traditional water resource planning approaches with public participation and collaborative computer modelling in order to identify problems, determine objectives and criteria for evaluation, and analyse trade-offs between alternative options.

It should be noted that there is a difference between stakeholder participation and conflict management. Participation is driven by articulation of interests and access, but this can increase as well as reduce the level of conflict. Conflict management is driven by the aggregation of interests and refers to the suite of tools available to deal with conflicts over interests and values. Both concepts may, however, use similar techniques at different times.

Useful resources

Publications

GWP (2000) Integrated Water Resources Management, Background Paper No. 4
GWP (2004) IWRM and Water Efficiency Plans by 2005: Why, What and How? Background Paper No. 10
GWP (2004) Catalyzing Change: Handbook for Developing IWRM and Water Efficiency Strategies
GWP (2017) Collaborative Modelling, Perspectives Paper

Tools

Regulation and Compliance (B1)
Water Supply and Sanitation Services (B2)
Coordination and Facilitation (B3)
Capacity Building (B4)
Stakeholder analysis (C3.02)
Communication (C5)
Raising public awareness (C8.02)

Case studies

Transboundary: Junction of land degradation, biodiversity loss and water resources management in Kagera and Nyando catchments of Lake Victoria basin (#384)
Benelux: Farmer participation in water conservation (#29)
Thailand: Partnership policy in Songkhla Lake (#269)
Estonia: Testing innovative public participation methods – citizens' jury and focus groups (#272)
Tanzania: Pangani River Basin: Building consensus on water allocation and climate change adaptation (#453)

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Example lectures
Role play game – hypothetical situation of a shared river

Video
Connecting Water and Energy (2014) GWP

Assessment instruments for decision-making

social, environmental, economic, and risk assessments

In order to achieve water security for an area, decision-makers need to not only understand the physical resource itself, but also the possible impacts that their management decisions have on those resources and the surrounding areas. For that reason, a good IWRM planning process should include social, environmental, economic, and risk assessments. To do this, the planning process must take into account not only development options within the water sector itself but also scenarios for development and relations among other sectors that may have an impact on the water resources (e.g. water demand or water quality). Likewise, the consequences of water management decisions in other economic sectors (e.g. tourism, agriculture, health) should be an integral part of the analyses made during the planning process.

Many methods are available to carry out assessments: geographic information systems are used to visualise massive amounts of spatially and temporally varying data from many different sectors; decision support systems help with the acquisition and management of such data and are mainly used to solve unstructured or semi-structured decision problems. Once the information is gathered, the range of assessment methods includes:

- risk assessment (and risk management)
- vulnerability assessment
- social assessment
- economic assessment
- environmental impact assessment.

Useful resources

Publications
WMO and GWP (2007) *Applying Environmental Assessment for Flood Management*
GWP (2002) Risk and Integrated Water Management, Background Paper No. 6
GWP (2013) The Role of Decision Support Systems and Models in Integrated River Basin Management, Technical Focus Paper No. 2

Tools
Assessment Instruments (C2)
Geographic information system (C3.01)
Shared vision planning (C3.03)
Decision support systems (C3.04)
Planning for IWRM (C4)
Water footprint (C8.03)
Virtual water (C8.04)

Case studies
Tanzania: Pangani River Basin: Building consensus on water allocation and climate change adaptation (#453)
Brazil: Integrated environmental assessment of agricultural production systems in the Toledo River Basin (#441)

Example lecture
Role play game – hypothetical situation of a shared river

5. Economics

Economic science studies human behaviour. Economics employs market forces and economic incentives to change the behaviour. Water is used as an input to economic activity such as irrigation, household and industrial water use, and hydropower generation. However, water also provides ecosystem services such as the maintenance of wetlands, wildlife support, and river flows for aquatic ecosystems. In economic language, the quantity problem is closely related to water scarcity (increasing demand and declining supply) for the competing uses of water resources or damage from floods in river basins, while the quality problem is related to water pollution, which may be caused by negative externalities. Economic science provides a framework for operationalising the concept of water as a social and economic good. In the traditional economic approach, any good has a price tag that is composed of various inputs. The activities impose externalities, and economic incentives are established to internalise these externalities. It is also important to employ economics in order to correct policy failures. "Many past failures in water resources management are attributable to the fact that water has been – and is still – viewed as a free good."[9]

Water economics and IWRM

Water economics provides a framework to assist in the allocation of scarce water resources among competing uses. In the trade-off between inter-sector water uses, the aspect of temporal variation in water availability and reliability of supply is crucial, and often overlooked by economists. The various water-using sectors require different levels of reliability in supply, which somehow has to be reflected in the price of water. The IWRM approach emphasises that water use includes both consumptive uses (e.g. irrigation) and non-consumptive uses (water left for use by the environment). This was recognised in an IWRM principle, stipulating that "Water is a public good and has a social and economic value in all its competing uses," (Dublin Principle No. 4). The IWRM approach helps to identify trade-offs that range from markets to mandates. Water economics studies the unique characteristics of water resources:

- Water can be both a renewable and a non-renewable resource.
- In its natural state, water is predominantly a common-pool resource.
- Water use can create negative externalities as well as significant positive externalities.
- Water use can be both a human right and a marketable good, requiring different management approaches.
- Water supply is variable, creating risk and uncertainty.

Water valuation instruments

Economic valuation serves as a basis for evaluating the trade-offs involved in the allocation of water resources among competing uses. A key to the valuation of water resources is to establish the functions that they fulfil. This means exploring the links between the structures and processes of water resources and the goods and services they provide that are valued by society. Values, costs, charges, and prices are all different concepts.

[9] GWP (2000) Integrated Water Resources Management, Background Paper No. 4, p. 18.

value of water

The value of water in alternative uses is important for the rational allocation of water as a scarce resource (using the 'opportunity cost' concept), whether by regulatory or economic means. The full value of water consists of its use value – or economic value – and its intrinsic value. Information on the economic value of changes in water policy can assist governments in setting policy and sector priorities. A comparison of the benefits and costs of planned changes in policy is required in order to establish whether they are potentially worthwhile. Water values are highly site-specific, being dependent on local uses, as well as season, water quality, and reliability.

charging for water

Charging for water is applying an economic instrument to affect behaviour towards conservation and efficient water usage, provide incentives for demand management, ensure cost recovery, and signal consumers' willingness to pay for additional investment in water services.

There are several methods to valuate water. Most of them assess willingness to pay for a good or service or to avoid the bad. Some valuation techniques are the contingent valuation method, hedonic property value, and travel cost method.

cost–benefit analysis

The problem facing decision-makers in the provision of a public good is how to compare different investment options and allocate resources in order to maximise the welfare of society. Water valuation techniques were developed for cost–benefit analysis of projects (not the national economy). Cost–benefit analysis is a tool to compare investments and allocate resources efficiently. The ratio of benefits to costs is used to assess whether an investment is an efficient use of funds.

Useful resources

Publications

GWP (1998) Water as a Social and Economic Good: How to Put the Principle into Practice, Background Paper No. 2
Cap-Net, UNDP, GWP and EUWI (2008) Economics in Sustainable Water Management, Training Manual and Facilitator´s Guide

Tools

Economic assessment (C2.06)
Payments for environmental services (C7.06)
Water footprint (C8.03)
Virtual water (C8.04)

Case studies

Costa Rica: Environmentally Adjusted Levies for Water Use (#378)
Transboundary: BEAM – Aral Sea Basin Economic Allocation Model (#432)

Video

Sand, Water, People, Profits (2013) TheWaterChannel

Water financing and pricing

investment

Sustainable development requires heavy investment. The investment is needed in the conservation, management, and development of the natural resources that underpin water supply (watersheds, catchments, river courses, wetlands, aquifers) as well as in the creation of hard and soft infrastructure that harnesses its services for humanity (pipelines, dams, treatment works, pumps, distribution systems, hydropower stations). The cost of this investment needs to be financed in various ways.

financed

IWRM calls for a clear policy framework that defines both robust investment strategy and transparent financial planning. This includes the definition of financing sources and of who shall pay, the definition of principles that guide financing (e.g. polluter pays principle, user pays principle, cost recovery), and the specification of the different economic and financing instruments that ensure financial resources are collected and transferred to wherever they are needed. Because of the inter-sector nature of IWRM, water financing will rely on financial sources from both the water sector and other economic sectors. Ultimate financing sources include taxes, transfers, and tariffs.

financing sources

There are good reasons for public budgets to prioritise public goods and activities with strong external benefits. Examples would be flood protection, meteorological and hydrological monitoring, and promotion of household hygiene. There are also external costs arising from the use of water (e.g. pollution), which can be penalised through taxes and charges according to the polluter pays principle.

water financing

Water financing was traditionally focused on financing drinking water supply and sanitation. In recent years, more attention has been paid to sustainable financing (balancing requests for funds with the likely revenues from users, tax-payers, and external transfers). Discussion has started on financing water resources management (soft investments in good water governance). The reason is that pouring finance into poor governance will not bring sustainable solutions. Financing of the whole water sector should be coherent, but different parts of it are likely to need different financial solutions.

water pricing

Water pricing is a powerful instrument and can create incentives. It leads to resource efficiency (i.e. less water is used to produce the same level of output). It also leads to allocative efficiency (i.e. water will be used for activities where it represents high value). Water pricing also has a revenue effect. There are different approaches, mechanisms, and tools for the design of water prices. Key issues around water pricing include:

resource efficiency

allocative efficiency

- clarifying the objectives of water pricing (incentive or/and revenue function)
- integrating water pricing into a full water financing strategy (to assess how much water pricing is expected to contribute to cost recovery)
- assigning roles to institutions and getting the process right (water pricing should be the result of a participatory planning process; agencies responsible should be both mandated to implement water prices and accountable to report on collection and spending of revenues; and consumers should be metered for water use)
- keeping the instrument effective; willingness to pay and ability to pay for water services should be assessed and not assumed.

subsidies

A special form of water pricing is the use of subsidies – financial assistance given by the government to certain groups (poor people, farmers). Although subsidies may be introduced with good intentions, they are difficult to remove, and may have unintended negative side-effects (harmful subsidies).

PES Novel categories of financing instruments are payments for ecosystem services (PES) and payments for tradable water-related rights (e.g. water abstraction rights, water pollution rights, or wetland development rights). In these negotiated payments, revenue is received by actors (rather than water authorities) to use directly for water resources management actions.

Useful resources

Publications
GWP (1998) Water as a Social and Economic Good: How to Put the Principle into Practice, Background Paper No. 2
GWP (2016) Beyond Increasing Block Tariffs, Perspectives Paper No. 8

Tools
Investments and Financing Structures (A3)
Economic Instruments (C7)

Case studies
Transboundary: BEAM – Aral Sea Basin Economic Allocation Model (#432)
Chile: System of households' water use subsidies (#404)
India: Issues in introducing a realistic water pricing regime in urban local bodies (#253)

Example lecture
Polluter pays principle in the water sector

6. Technical infrastructure

Water infrastructure and water-related technologies are essential for many human activities. For example, infrastructure related to water supply and wastewater treatment is necessary to ensure a good quality of life and health in communities and cities. Reservoirs and irrigation systems are fundamental for agriculture/ livestock sustainability. Finally, dams for energy production, channels for navigation/ communication, flood relief structures, and artificial water bodies for recreation or landscaping are further examples of the importance of water infrastructure. Technological innovations are key to creating more efficient water distribution systems. Water efficient appliances, drip irrigation systems, and hydroponic agriculture are just three examples of technological solutions for reducing water consumption.

Choosing the right infrastructure and/or technological solutions is a key factor in guaranteeing good management of the water resource. The selection process must consider not only economic aspects and environmental impacts, but also the effect on local communities. In the case of big infrastructure projects, necessary legal frameworks and institutional capacities should be reviewed. For these reasons, the application of IWRM concepts and tools has become a proven and widely accepted method of ensuring good decision-making processes towards sustainable solutions.

This teaching component includes three teaching subjects: Hydraulic structures, Water supply and wastewater treatment, and Technical innovations. These subjects are representative of most issues relating to technical infrastructures.

Hydraulic structures

Classical hydraulic structures include:
- channel regulating structures such as weirs or gates
- water intake or outlet structures
- flow measurement structures such as flumes
- dam spillways
- energy dissipation structures.

Designing hydraulic structures requires a good understanding of the fluid mechanics principles that control water flow in hydraulic systems. These structures are not only critical to ensuring a sustained flow of water for demand and supply requirements, but are also the basis for monitoring and evaluating the behaviour and performance of the hydraulic systems.

The importance of hydraulic structures in IWRM is partly due to their function as basic elements in the data collection and monitoring processes. They are also fundamental in providing the necessary water security for agricultural, hydroelectric, and human consumption activities. IWRM emphasises that decision-making processes should be the result of a coordinated effort among different stakeholders in a basin or a region. However, to fulfil this goal it is necessary for stakeholders to understand the scale and impact of these structures. It is also very important for engineers and technical professionals not only to explain the benefits of hydraulic structures to those stakeholders, but also to take into consideration their opinions and experiences from the early stages of a project.

Useful resources

Publications
GWP (2012) Integrated Urban Water Management, Background Paper No. 16

Tools
Demand and supply (C1.01)
Data collection (C1.02)
Monitoring and evaluation systems (C1.03)

Case studies
India: Towards A Better Life? A Cautionary Tale of Progress in Ahmedabad (#472)

Videos
Punjab’s flood of the century (2015) Provincial Disaster Management Authority Punjab at TheWaterChannel
Web presentation: Design of spate flow diversion and distribution structures (2012) TheWaterChannel

Water supply and wastewater treatment

Water supply and wastewater treatment are basic indicators of a society’s health and quality of life. In each case, it is necessary to achieve certain water quality goals set by national and international standards. Therefore, engineers should have not only a solid understanding of physical, chemical, and biological principles supporting water treatment processes and technology, but also a clear knowledge about administrative, institutional, and operational processes and frameworks.

From an IWRM perspective, a sustainable water supply system and infrastructure that involves all stakeholders is fundamental to the fulfilment of two strategic goals:

- efficiency, to make water resources go as far as possible
- equity in the allocation of water across social and economic groups.

On the other hand, wastewater treatment is crucial to a third strategic goal of environmental sustainability, to protect the water resource base and associated ecosystems.

Demand and supply projections, data collection programmes, and monitoring of quality are issues to consider in both supply and treatment, in order to ensure good decision-making processes within these systems. Finally, a recycling process and reuse of water should be considered following wastewater treatment of effluents, as a way to increase water supply for certain activities.

Useful resources

Publications

GWP (2012) Integrated Urban Water Management, Background Paper No. 16
GWP (2009) Managing the Other Side of the Water Cycle: Making Wastewater an Asset, Background Paper No. 13

Tools

Public sector water utilities (B2.01)
Private sector water services providers (B2.02)
Community-based water supply and management organisation (B2.03)
Demand and supply (C1.01)
Data collection (C1.02)
Monitoring and evaluation systems (C1.03)
Demand efficiency (C6.01)
Supply efficiency (C6.02)
Recycle and reuse (C6.03)

Case studies

Spain: Segura River returned to its health (#478)
Armenia: Local solutions for waste water management in Armenia village (#438)
Czech Republic: Implementation of sustainable sanitation in rural areas; an integrated approach in Hostetin (#467)

Videos

Managing wastewater in a water sensitive city - full resource recovery (2013) Zenrainman at TheWaterChannel
From waste to water: greywater reuse in The Middle East (2006) International Development Research Centre (IDRC) at TheWaterChannel

Technical innovations

Technical innovations to ensure increased efficiency in water systems are crucial in order to guarantee a sustainable water supply to people around the world. Population growth, changing demographics, and climate change effects on hydroclimate variables are just three examples of ongoing processes that reduce the lifespan of almost any engineering solution to water supply/demand problems. Technical innovations are usually applied to water systems at different scales, to increase supply or demand efficiency.

On a household scale, employing water efficient showers, toilets, taps, and appliances are examples of technical solutions that can make a difference when widely employed in a city. At the industrial level, reducing pressure in some processes or reusing water when possible are also innovative ways to reduce demand. In agriculture, employing drip irrigation instead of flooding irrigation can also reduce water demand. Rain harvest technology or storm-water control measures are good instruments to increase water supply. In this way, technical innovations can reduce the necessity for new water supply or wastewater treatment facilities.

From an IWRM perspective, technical innovations should be accompanied by a change in water culture, making individuals more conscious of the necessity to save water (especially in countries with abundant water resources). Proper legislation and incentives are also important to promote new technologies to citizens and to the industrial and agricultural sectors.

Useful resources

Publications

GWP (2012) Integrated Urban Water Management, Background Paper No. 16
GWP (2009) Managing the Other Side of the Water Cycle: Making Wastewater an Asset, Background Paper No. 13

Tools

Demand efficiency (C6.01)
Supply efficiency (C6.02)
Recycle and reuse (C6.03)

Case studies

Mediterranean: Non-Conventional Water Resources Programme (#464)
Poland: Small retention – Big deal; national programme to improve water balance (#473)

Videos

Non-Conventional Water Resources Programme in the Mediterranean (2016) GWP Med
Small Water Retention Measures (2014) GWP CEE
Environmentally friendly wastewater treatment (2006) UNDP at TheWaterChannel

CHAPTER 3. EXAMPLE LECTURES

Example lecture 1: Institutional cooperation on transboundary watercourses

Prerequisite	This lecture goes beyond the basics in water law (Tool A2.01: Elements of water law). To engage in this lecture, students should have an understanding of the concepts of international law and international policy.
Duration	The duration is 90 minutes.
Content	The lecture gives an introduction to interstate institutional cooperation (B1.02: Transboundary organisations for water resource management) as a crucial issue of water governance, to equip students with an understanding of how institutional mechanisms perform their functions in practice to avoid or solve disputes (C5.01: Conflict management). It is also important to explain the implementation of the outcomes of institutional cooperation taking place in a transboundary context into the national water system (Regulatory bodies and enforcement agencies). It is best to teach this lecture in two parts. The first part familiarises students with an understanding of the role and relevance of joint institutional mechanisms in the management of international watercourses. It discusses the main types of institutional mechanisms currently existing in shared watercourses. In the second part, the lecture focuses on the mandate, functions, and principal activities of joint institutions.
Learning objective	The objectives are (i) to gain sound knowledge of interstate institutional cooperation that facilitates the use, sharing, management, and protection of water resources according to international water law; (ii) to acquire an in-depth understanding of the features of the institutional framework related to the legal aspects of transboundary water governance; (iii) to foster reflection allowing a more effective use of legal institutional frameworks in the process of interstate water management.
Methods	The lecture includes a presentation, a class discussion, the interpretation of legal texts, and analysis of the IWRM ToolBox case to identify the importance of institutional cooperation.
Lecture	First, the definition of institutional cooperation within international water law is presented to the students.
Discussion	Then an interactive discussion is encouraged. The students discuss the meaning and framework of institutional cooperation according to international water law.
Interpretation	After a discussion, students work on international and regional sources of law. They interpret treaties and declarations providing for principles and instruments of institutional cooperation that exemplify best international practices of transboundary cooperation, allowing for their proper comprehension.
Case study	Then the students move on from legal text to work on a case study from the IWRM ToolBox. The case study shows the transboundary water compact administration in arid regions of the USA. The students will reflect on the use of transboundary cooperation, and discuss the specific meaning of the solutions successfully applied to the particular situation presented in the case study.

Case study	The learning approach may be complemented by practical collaborative activities, such as comparative analysis of international and national law sources with a focus on international cooperation fixed in national law. The learning process during this lecture is evaluated with work on further case studies. Students analyse a case and assess the applicability of the proposed solutions to institutional cooperation on transboundary watercourses of their country of origin.
Tools	A2.01, B1.02, B1.04, C5.01
Related material	Asian Development Bank (2009) *Water Rights and Water Allocation: Issues and Challenges for the Asian Region*. ADB, Mandaluyong City, Philippines. Bruhacs, J. (1992) *The Law of Non-Navigational Uses of International Watercourses*. Martinus Nijhoff Publishers, Dordrecht, pp. 121–208. Caponera, D.A. (1992) *Principles of Water Law and Administration – National and International*. Balkema Publishers, Rotterdam, Brookfield. GWP (2013) International Law – Facilitating Transboundary Water Cooperation, Background Paper No.17. Vinogradov, S.V., Wouters, P. and Jones, P. (2003) *Transforming Potential Conflict into Cooperation Potential: The Role of International Water Law*. UNESCO, Paris. Available at: http://unesdoc.unesco.org/images/0013/001332/133258e.pdf.

Example lecture 2: Cultural heritage and spiritual aspects of water

Prerequisite	This lecture is designed for graduate students with no further prerequisites.
Duration	Duration is 4 hours and intended to be held as a block course.
Content	This lecture focuses on a part of water resources management that is not often given much attention. On the one hand it focuses on the connection between societies and water in culture and on the other hand it shows that societies often also have a spiritual connection to water.
Learning objective	The objectives are to (i) understand that indigenous societies have a spiritual connection to water and that this awareness is part of their culture; (ii) compare how indigenous societies see water in comparison to Western societies; (iii) analyse how land use can affect water availability and how this impact on water can affect cultural heritage. Students will then be able to describe lessons learned from presented studies with a special focus on participatory processes.
Methods	Methods include introductory videos, answering of questions, group discussions, analysing literature, and presentation.
Videos	As an introductory activity students are asked to watch the video ‘Creation Story’. This and other educational videos are the result of the 3-year research project, ‘The Sacred Relationship’, by the Native Counselling Services of Alberta, guided by a circle of Cree elders and led by a team of native and Western scientists aiming to reconcile the relationship between aboriginal people and the rest of Canada. The project features a documentary film, educational curriculum, and a public policy research article. The short (4 min) video ‘Creation Story’ shows how an elderly indigenous man explains the importance of storytelling to pass on the knowledge about nature conservation and mutual respect from generation to generation.
Discussion	After seeing the video, students are asked to discuss its content, led by the following questions: 1. What does the elder say that water is, when he first begins to tell the story? 2. The elder says that the creator asked four women to come here to this world. What do they represent?
Text interpretation	After this introductory activity, the students are divided into groups to read the article from La-Boucane-Benson et al. (2012). The authors discuss the findings from ‘The Sacred Relationship’ project. The paper discusses how colonial policy has created despair and disconnectedness from water in native communities. They then present a framework for the development of polices to repair the relationship between mainstream society and the aboriginal communities. First, all groups read the introduction and methods sections (pages 3–6). Then, the paper is divided and each group reads a separate section. 1. Pre-Contact Worldview section. 2. The Nature of the Sacred Relationship 3. Colonial Policies of Domination and Assimilation 4. Impact of Colonisation 5. Policies that Promote Pimatisiwin 6. Reclaiming Worldviews + Reconciliation + Self-Determination

Presentations	After reading, the chapter may be discussed within the group. When the group has mutual understanding of the chapter, a short presentation of what they have read and discussed is prepared and presented to the rest of the class.
Text interpretation	After all groups have presented, the connection between the text and the introductory video is drawn out, by asking the students what they see as the connection between their presented chapter and the video. They may be asked (i) to think about the symbolic meaning of the video scene where a drop hits the pool of water or (ii) what do the ripples represent about learning from a story? These questions stimulate a discussion between the students. The discussion will be followed by the analysis of a second text. Students are asked to read the article from Groenfeldt (2006), which focuses on the difference in how water is valued. While indigenous societies give great spiritual value to water, Western societies predominantly value water in an economic way. A better understanding of indigenous value systems, Groenfeldt argues, will help Western societies relieve cultural pressure on indigenous societies and may benefit the cause of sustainable development.
Writing	Students will then write a framework of a new short educational video to communicate the relationship between water and spiritual values according to the viewpoint of indigenous societies. This is a new ripple, to give value to aboriginal culture and knowledge.
Text interpretation	Finally, students will read the article by Whitman et al. (2014), who discuss using local materials and indigenous architecture to improve sustainability. The students' task is to identify why water scarcity can prejudice efforts to promote cultural heritage, and what is the role of traditional Mapuche architecture in their social traditions. This is done with special attention to the materials (reeds) used to build their houses ('ruka') and how water is important to the availability of these materials. Furthermore, students may focus on what features a participatory management process of land use and water-related issues should have.
Tools	B2.01, C1.01, C1.02, C4.01, C4.03, C5.01, C5.02, C6.01
Related material	Boelens, R., Chiba, M. and Nakashima, D. (Eds) (2006) *Water and Indigenous Peoples*. Knowledges of Nature Vol. 2. UNESCO, Paris. Groenfeldt D. (2006) Water Development and Spiritual Values in Western and Indigenous Societies. pp. 108–117. In: *Water and Indigenous Peoples* (Boelens, R., Chiba, M. and Nakashima, D., Eds). Knowledges of Nature Vol. 2. UNESCO, Paris. Available at: http://unesdoc.unesco.org/images/0014/001453/145353e.pdf LaBoucane-Benson P., Gibson G., Benson A. and Miller G. (2012) Are We Seeking Pimatisiwin or Creating Pomewin? Implications for Water Policy. *The International Indigenous Policy Journal*, **3**(3). DOI: 10.18584/iipj.2012.3.3.10. Available at: http://ir.lib.uwo.ca/iipj/vol3/iss3/10 Whitman, C.J., Armijo P., G. and Turnbull, N.J. (2014) The Ruka Mapuche: clues for a sustainable architecture in southern Chile? pp. 759–761. In: *Vernacular Architecture: Towards a Sustainable Future* (Mileto, C., Vegas, F., Garcia Soriano, L. and Cristini, V., Eds). Taylor and Francis Group, London, UK. Available at: http://orca.cf.ac.uk/69730/1/whitrm.pdf Video: 'Creation Story' at http://www.sacredrelationship.ca/videos/

Example lecture 3: Water conservation

Prerequisite	There are no prerequisites. However, introductory lectures in economy and law are helpful.
Duration	Total duration is 12 hours, taught in a series of small sessions.
Content	Dealing with the instruments of water conservation, this lecture reviews different legal and financial tools. These include water resources policies, water law, and other related legal frameworks but also investment and strategic financial planning and economic instruments. In the second part, the lecture focuses on specific laws and policies being employed in Panama and a discussion of their effectiveness in the context of IWRM.
Learning objective	The objectives are to (i) become familiar with the general concepts; (ii) put national laws and policies in perspective; (iii) analyse the effectiveness of specific laws or policies.
Methods	The lecture is based on several IWRM ToolBox tools and case studies. The main methods of teaching include reading exercises in class, activities, and assignments.
Reading	Students are asked to read through relevant Tools (A1 Policies; A2 Legal Frameworks; A3 Investment and Financing Structure; and C7 Economic Instruments). This exercise gives a theoretical overview and the knowledge for students to dive into real-life case studies.
Presentation	Students then read different case studies and present representative cases in specific countries or regions. The presentation should include a general follow-up of the current situation compared to the situation when the case was written.
Discussion/ Debate	Focusing on the context of Panama, or any other country, the students get into a group discussion guided by the question: How did the legal and financial framework within Panama make a difference in the results obtained by the Panama Canal and IDAAN, the National Institute of Aqueducts and Sewers in Panama? The last group exercise is a debate among students. Three river basins (A, B, C) are described and data sets are provided (population, economy, hydrological regime, water uses, pressures). The debate will then be based on the question: If you have financing to develop a basin-management plan, which basin (A, B, or C) will you choose?
Tools	A1, A2, A3, C7
Related material	Panama Government (2016) National Plan for Water Security 2015–2050: Water for Everyone.

Example lecture 4: Hydrology and IWRM

Prerequisite	This lecture is designed for undergraduate students with a basic knowledge of hydrological principles.
Duration	The duration of the lecture is 4 hours.
Content	The lecture focuses on an introduction to the hydrological principles within the IWRM approach, with practical examples from Panama. This lecture is one of the last classes within the hydrology course. Therefore, the students already have a general overview of the driving physical processes that explain water flows and volumes within a basin.
Learning objective	The learning objectives are to (i) gain a basic understanding of IWRM; (ii) to get a holistic perspective on the importance of hydrological principles learned during the semester; and (iii) to analyse how one of the main engines of the Panamanian economy rests not only on solid hydrology principles, but also on integrated watershed management.
Methods *Lecture*	As an introduction, a 2-hour class is given with two objectives: (i) to teach the fundamentals of IWRM, and (ii) to teach the basics about three case studies entitled: 'The management of the Panama Canal Watershed' (#5), 'Integrated watershed management in Carabobo State' (#426), and 'Jamaica: Pathway of Jamaica towards IWRM Approach: Case study of the Rio Minho Watershed in Clarendon' (#474).
Preparation	The students are given all case studies two weeks in advance of this lecture, and are required to review them.
Discussion	A second 2-hour class follows the introductory class and it will focus on the students' ability to see the relationships between physical hydrological processes within the cases used as examples. Discussions will be guided by some general questions such as: 1. In the case of the Panama Canal (#5), are the statements made by the author in the 'lessons learned' section still relevant for today? 2. How are hydrology principles applied in the case studies (#5, #426, and #474) employed as examples?
Related material	**Hydrology principles** Linsley, R.K, Kohler, M.A.Y. and Paulhus, J.L.H. (1982) *Hydrology for Engineers*. Third Edn. Mc Graw-Hill Book Co., New York. Maidment, D.R. (Ed) (1993) *Handbook of Hydrology*. McGraw-Hill Inc., New York.
Case studies	Panama: The management of the Panama Canal Watershed (#5) Venezuela: Integrated watershed management in Carabobo State (#426) Jamaica: Pathway of Jamaica towards IWRM Approach: Case study of the Rio Minho Watershed in Clarendon (#474)

Example lecture 5: 3D model of a water basin

Prerequisite	This lecture is designed for undergraduate students and there are no prerequisites.
Duration	The total duration is 12 hours and the lecture is best divided into 3–4 separate sessions.
Content	The lecture is based on practical work, with the students building a 3D model of a river catchment in an area they are familiar with. Students will use printed topographic maps and styrofoam to construct a three-dimensional watershed model and discuss the water-related processes.
Background	This lecture was developed for the first time within a set of environmental education activities aiming to develop a participatory management approach to water resources with a rural community located in the hydrographic basin of the Upper Maranhão River in Brazil.[10] The 3D model of a water basin provided the necessary abstraction to enable the practitioners to visualise the topographic shapes present in maps. The activity also helped people to localise and understand the relationship among landscape elements, as one participant put into words: ''My land is more or less at here, the bridge to Planaltina de Goia's is here, and the waterfall of Maranhão river is here. Thus, everything what happens in this part upstream (like the pig farm) influence this part, downstream, because the water runs to there, right?'' The following concepts were handled in a sequence of discussions that configured an action research spiral: hydrographic basin, cartography, mapping scales, geoprocessing, remote sensing, and the National Policy of Water Resources. Later, with undergraduate students at the University of Brasilia, the same activity was conducted as described in this example.
Learning objective	The learning objectives are (i) to visualise the topographic shapes present in maps and (ii) to help students localise and understand the relationship among landscape elements and influences in a watershed.
Methods	The method is a practical hands-on exercise to build the model, followed by discussion.
Building the model	The steps in building the model are: 1. Analyse a topographic map of the study area and identify the contour lines. 2. Print one topographic map for each of the contour lines. 3. Cut and glue the altimetric layer on to styrofoam. 4. Cut the styrofoam to produce separate altimetric layers. 5. Glue the altimetric layers one on top of another. 6. Sand the border surface and cover it with plaster. 7. Paint the 3D model of the water basin, especially the river course. After finishing the 3D model, students are asked to find rivers that are not identified in the original topographic maps. There are usually some smaller streams not shown on the topographic maps due to the scale of analysis. Nevertheless, we can now find the 'invisible' streams based on the morphology of the terrain.
Discussion	The 3D model is then used to discuss (i) the Strahler stream ordering process to find the springs, (ii) the river continuum concept,[11] and (iii) the riverine productivity model,[12] which have now been integrated into a new view, proposed by the river wave concept.[13]

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[10] This activity was briefly commented on in Berlinck, C.N. and Saito, C.H. (2010) Action Research for Emancipation Informed by Habermas and Hierarchy of Systems: Case Study on Environmental Education and Management of Water Resources in Brazil. *Systemic Practice and Action Research*, **23**(2): 143–156.

[11] Vannote, R.L., Minshall, G.W., Cummins, K.W., Sedell J.R. and Cushing, C.E. (1980) The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences*, **37**: 130–137.

[12] Thorp, J.H. and Delong, M.D. (1994) The riverine productivity model: An heuristic view of carbon sources and organic processing in large river ecosystems. *Oikos*, **70**: 305–308.

[13] Humphries, P., Keckeis, H. and Finlayson, B. (2014) The river wave concept: integrating river ecosystem models. *BioScience*, **64**(10): 870–882.

Example lecture 6: Understanding IWRM ToolBox case studies supported by concept maps

Prerequisite	There are no prerequisites for this class.
Duration	The duration is 8 hours. It can be divided into several sessions.
Content	A concept map is considered a powerful technique to promote integration among different knowledge areas[14] and to consolidate interdisciplinary knowledge.[15] This example shows how students can develop a concept map based on different case studies from the IWRM ToolBox. A concept map is a graphical representation of knowledge that allows rapid visualisation of concepts. The concepts are enclosed in geometric figures (boxes or circles) and interconnected by connecting lines that can have a label or linking words attached (Novak and Cañas, 2007).[16] Concept maps can promote easy comprehension of a set of relationships, and thus can "improve communication between experts and ordinary people as an educational activity, as well as facilitate communication among the experts themselves who are usually isolated in their specialties" (Saito, 2016, p.6).[17] As graduate students often have different backgrounds, it is equally beneficial for them.
Learning objective	The learning objectives are to (i) understand how different concepts are connected; (ii) identify gaps in a knowledge chain; (iii) understand a process or address an unsuspected connection between concepts.
Methods	The method is to develop the concept maps in a workshop-style class, including introductory presentations, group work, and concluding discussions. The lecture methods and contents are based on the IWRM ToolBox Workshop held in São Paolo in 2015.[18] First, the complete texts of different case studies are printed and distributed to the students. The content of each case study is presented to the students, and a list of the main issues in the case studies is handed out as a reminder. Alternatively, students may be asked to read and understand the case studies as preparation for the lecture. Students are then divided into groups to develop a collective learning process and begin drawing the concept maps. Each group begins to draw a concept map for one case study. The concept maps can be hand-designed on a sheet of paper, or developed in software such as CmapTools.[19] It is expected that students will learn while they discuss what concepts they should extract, what concepts should be connected to, and why they should connect different concepts.
Presentation	After the concept maps have been produced, a representative of the group presents what they have understood and appreciated most.
Group work	The students then discuss together how they could capture the connections of IWRM within the concept maps.
Discussion	During the workshop one result of the discussion was that "Different types of connections could be seen: interlinkages among action – outcome – lessons learned; interconnections

Discussion	among environmental impact diagnosis, socio-environmental conflicts, environmental fragility, and resilience; linkage between technical solutions and community empowerment." At the end of the class, the lecturer can discuss with the students how concept maps could help to indicate a lack of understanding revealed by difficulty in making connections during group work, and how concept maps could help them to clarify the interconnections.
Tools	A1.02, A2.02, A3.01, C1.01, C2.05, C5.01, C6.02, C7.02
Case study	Slovakia: Ruzinov Strkovec Lake in Bratislava (#275)

[14] Heemskerk, M., Wilson, K. and Pavao-Zuckerman, M. (2003) Conceptual models as tools for communication across disciplines. *Conservation Ecology*, **7**(3), article 8. Available at: http://www.consecol.org/vol7/iss3/art8/ [Retrieved 3 June 2016].
[15] Daley, B.J. (2004) Using concept maps in qualitative research. pp. 191–197. In: *Concept maps: Theory, methodology, technology — Proceedings of the first international conference on concept mapping* (Cañas, A.J., Novak, J.D. and González, F.M., Eds). Universidad Pública de Navarra, Pamplona, Spain.
[16] Novak, J.D. and Cañas, A. J. (2007) Theoretical origins of concept maps, how to construct them, and uses in education. *Reflecting Education*, **3**(1): 29–42.
[17] Saito, C.H. (2016) Concept map for environmental education planning: capacitation of volunteers for the FIFA Football World Cup in Brazil. *Journal of Education for Sustainable Development,* **10**(2): 289–308, first published on July 7, 2016 as doi:10.1177/0973408216651944.
[18] During the GWP IWRM ToolBox Workshop for university lecturers in South America, held in São Paulo, Brazil, on December 9–10, 2015, three case studies were presented to participants and submitted to a working group analysis based on the concept maps.
[19] Available for free download at http://cmap.ihmc.us/. This method is usually preferred because it permits exchange of digital files and image projection by data show, which can be an opportunity to debate with students in class.

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Example lecture 7: How wolves change rivers

Prerequisite	There are no prerequisites for this lecture.
Duration	The duration is 4 hours, taught as a block course.
Content	The class can be part of a basic ecology course or part of a series on ecosystems and water security. To teach the concept of trophic cascade and to exemplify interdependencies in nature, students are shown the video 'How wolves change rivers' (https://www.youtube.com/watch?v=ysa5OBhXz-Q). This is followed by discussion, and the production of concept maps.
Learning objective	The learning objectives are to understand and be able to describe (i) the concept of trophic cascade and (ii) interdependencies in nature.
Methods	After watching the short video, students are asked to describe the trophic cascade in the story, and explain how a living being can interact with a physical entity like a river.
Concept map	A concept map can help to describe both the trophic cascade and the relationship between wolves and rivers.
Tools	C1.01, C1.03, C4.03
Related material	To help produce strong and secure concept maps, students are asked to read at least three of the scientific articles listed below. Beschta, R.L. and Ripple, W.J. (2006) River channel dynamics following extirpation of wolves in northwestern Yellowstone National Park, USA. *Earth Surface Processes and Landforms*, **31**(12): 1525–1539. Beschta, R.L. and Ripple, W.J. (2008) Wolves, trophic cascades, and rivers in the Olympic National Park, USA. *Ecohydrology*, **1**(2): 118–130. Beschta, R.L. and Ripple, W.J. (2010) Recovering Riparian Plant Communities with Wolves in Northern Yellowstone, USA. *Restoration Ecology*, **18**(3): 380–389. Beschta, R.L. and Ripple, W.J. (2012) The role of large predators in maintaining riparian plant communities and river morphology. *Geomorphology*, **157–158**: 88–98 Marshall, K.N., Thompson Hobbs, N. and Cooper, D.J. (2016) Stream hydrology limits recovery of riparian ecosystems after wolf reintroduction. *Proceedings of the Royal Society (Series B)*, **280**: 20122997. Ripple, W.J and Beschta, R.L. (2012) Trophic cascades in Yellowstone: The first 15 years after wolf reintroduction. *Biological Conservation*, **145**(1): 205–213. Ripple, W.J., Larsen, E.J., Renkin, R.A. and Smith, D.W. (2001) Trophic cascades among wolves, elk and aspen on Yellowstone National Park's northern range. *Biological Conservation*, **102**(3): 227–234.

Example lecture 8: Privatisation of water services

Prerequisite	None; however, graduate level is required.
Duration	The duration is 4 hours, taught as a block course.
Content	The content mainly concerns the privatisation of water and the question of water rights, combined with the real-life example of a conflict in Cochabamba, Bolivia.
Learning objective	The objectives are for the students to (i) understand the foundations of the arguments against different approaches to water management, such as privatisation and water as an economic good versus a human right (individual and collective); (ii) compare the 2nd World Water Forum in The Hague (2000) and the Human Rights-Based Approaches and Managing Water Resources publication by UNDP and SIWI (2012); (iii) compare both statements to the Dublin Statement of 1992. Analyse how ideas from the 2nd World Water Forum and the UNDP publication are present in the Bolivian conflict about access to water.
Methods	Divide the students into three groups. The first group will receive *The Dublin Statement on Water and Sustainable Development* (1992). The second group will receive the text, *Ministerial Declaration of The Hague on Water Security in the 21st Century*, from the 2nd World Water Forum (2000). The third group will receive the publication, *Human Rights-Based Approaches and Managing Water Resources* (2012).
Interpretation of text	Allow each group 40 minutes to read the text, discuss it within the group, and prepare a presentation summarising the text they have read for the other students.
Presentation	Each group then presents to the other students.
Debate	A debate can be held after the three presentations. This debate should be based on Bakker (2007), which the students should read beforehand.
Interpretation of text	All students should then read the case studies in the IWRM ToolBox entitled ‘Bolivia: The water war to resist privatisation of water in Cochabamba’ (#157) and ‘Chile: System of households’ water use subsidies’ (#404).
Video	After reading both texts, all students watch two videos: ‘Water privatisation in Latin America’ (5 minutes) and ‘Right to water – Cochabamba’ (4 minutes). The students should debate the following questions: 1. By what means was water being privatised? 2. Do water privatisation policies oppose the idea of affordable water? 3. Is the right to water an individual or collective right? 4. Would improving efficiency of the water companies lead to any possible solutions?

Tools	A1.02, A2.02, C1.01, C2.05, C4.03, C5.01, C5.02, C5.03, C6.01, C6.03, C7.01, C7.03
Case studies	Bolivia: The water war to resist privatisation of water in Cochabamba (#157) Chile: System of households' water use subsidies (#404)
Related material	Bakker, K. (2007) The commons versus the commodity: 'Alter'-globalisation, anti-privatisation and the human right to water in the global South. *Antipode*, **39**(3): 430–455. The World Water Council (2000) *Ministerial Declaration of The Hague on Water Security in the 21st Century*. UNED (1992) *The Dublin Statement on Water and Sustainable Development*. Water Governance Facility (WGF) (2012) *Human rights-based approaches and managing water resources: Exploring the potential for enhancing development outcomes*. WGF Report No. 1. SIWI, Stockholm. **Videos:** Water privatisation in Latin America (2013) at https://www.youtube.com/watch?v=dL7E2e7q0Q4 Right to water in Cochabamba (2015) at https://www.youtube.com/watch?v=W92x9UcPJRk

Example lecture 9: The economics of climate change adaptation

Prerequisite	This course requires candidates to have a background in environmental science, water resources, forestry, agriculture, law, social science, economics, or other related fields.
Duration	The duration can vary between 6 and 12 hours and is best taught in a series of short sessions.
Content	The absence of certainty about the future consequences of climate change poses a dilemma as to what actions should be undertaken today. However, uncertainty does not mean that possible actions to reduce the consequences of climate change should be postponed until the uncertainty is resolved. Uncertainty is unavoidable in adaptation to climate change due to inadequate data, the unknown efficacy of adaptation actions, and uncertainties inherent in forecasting climate change. Adaptation measures come with a range of costs, with associated implications for the need for financial investment. Furthermore, in the presence of limited resources and a wide range of measures requiring the same resources, adaptation strategy choices involve trade-offs among multiple policy goals. The economics of climate change adaptation offers a range of techniques appropriate for conducting analysis in the face of uncertainties, and the choice of the most appropriate options for decision-making. The course uses tools such as cost–benefit analysis and related approaches including time dimensions, multimetrics, and non-probabilistic methodologies that evaluate no/low regret options. This helps decision-makers to wisely allocate resources where most benefits accrue, both socially and economically.
Learning objective	The aim of this course is to introduce students to both the theory and application of methods and data to estimate the costs and benefit of adaptation measures. A number of concepts linked to cost–benefit analysis such as internal rate of return, net present value, travel costs method, discounting and climate change, willingness to pay, and adaptation are examined in terms of their uses, similarities, and respective importance to adaptation option evaluation. The course also offers the students an understanding of the differences between adaptation and its achievement as a function of costs, barriers, behavioural biases, and the resources available to implement adaptation measures. Finally, it provides the students with valuable insights into trade-offs of options and the wider socio-economic consequences.
Methods	The course is based on the IWRM ToolBox tools, case studies, and Water, Climate and Development Programme (WACDEP) training materials. The main methods of teaching include lectures, reading, exercises including class assignments, and discussions.
Reading	GWP (2009) Water Management, Water Security and Climate Change Adaptation: Early Impacts and Essential Responses, Background Paper No. 14
Tools	A1.03, C4.07
Case studies	Transboundary: Building Climate Change Resilience through Community Action: A Transboundary Case of Lake Cyohoha in Bugesera (#484)

Example lecture 10: Assessment of risk for waterborne disease and how this can be an instrument for social participation

Prerequisite	None
Duration	4 hours
Content	Local planning and the set of priorities for budgets and investments based on risk and vulnerability assessment, considering the association between flood and waterborne diseases.
Learning objective	The aim is to demonstrate that geoprocessing is a methodology that can go beyond geographic information system technology to become a system to support collective decision-making. The lecture broadens the understanding of participatory decision-making about local budget priorities, encouraging rational solidarity and cooperation based on a risk assessment of waterborne diseases.
Methods	Students work on a map of the urban area of their city. If there is no sewer system map available, they can produce a data approximation by using demographic census data, where they can find information on which houses have a septic tank, rudimentary sewage tank, open-air sewage disposal, or a sewage collection system. In Brazil, these data are organised by census sectors within an urban area. The same census data can offer information about income. Once these census sectors have spatial delimitation, the students can create thematic maps of sewage disposal systems, family income, family education level, etc. Students should also produce a map of flood-prone areas in their city. All these maps can be handled in a geographic information system or in a manual way, designing contours and labels on a sheet of translucent paper. The students then overlay these layers. In those areas where flooding and bad sewage conditions (rudimentary sewage tanks or open-air sewage disposal) coincide, there can be a very high risk of waterborne disease. Additionally, students can overlay maps of high-risk areas and family income to find the most vulnerable families and their location in the city.
Comments	Where high-risk areas exist, students can go on to consider what can be done about this. In many cities in Brazil, neighbourhoods and districts decide what kind of actions their budgets should be used for, and this is considered a very participatory process. Nevertheless, people usually see only their own interests, and debate how to use the budget in their own neighbourhood. They never consider the possibility of deciding not to use any of their budget there but to add it to other neighbourhood budgets to solve a core problem in their city – drainage structure and sewage systems – in order to prevent the risk of epidemics of waterborne diseases. A good assessment with spatial analysis can help people to take wiser decisions and practise solidarity. This can be a real, rationally oriented participatory process.

Tools	A3.01, B2.01, B4.03, B4.04, C2.01, C2.02, C3.01
Case studies	Ethiopia: WASH Movement for better sanitation and hygiene (#335) Haiti: The Impacts of the 2010 Earthquake on Water and Sanitation in Port-au-Prince (#469)

Example lecture 11: Lesson from history – how the water–cholera relationship was understood

Prerequisite	None
Duration	2 hours
Content	The lecture shows how the relationship between water and cholera was first established with the support of spatial analyses, using a case study of a cholera outbreak in London in 1854.
Learning objective	The objective is to understand how systematic investigation can lead to valuable results by means of causality chains, using the example of the connection between water and cholera in the 19th century.
Methods	Students watch the two videos in sequence about the cholera outbreak in London 1854, and how Dr John Snow solved the problem by identifying the source of the disease. The set of videos will show the story of the investigation by Dr Snow and then an animation video of the 1854 cholera outbreak in Soho, London. It underlines the power of spatial analysis in diagnosis of the water–health relationship.
Videos	The Cholera Outbreak of 1854 (https://www.youtube.com/watch?v=Pq32LB8j2K8), (6 minutes). An animation of the 1854 cholera outbreak in Soho (https://www.youtube.com/watch?v=5JbtHiFXbU0), (4 minutes). Print the map on the screen of the second video, at the following dates: August 24, 28, 31 and September 3, 5, 8. Ask the students to connect all the dots to each other by a thin line, and identify the location where most of the lines cross over.
Comments	In the middle of the 1800s, people did not have a water supply direct to their houses. They had communal pumps to provide water and septic systems were primitive. When we provide pumps in distant communities today, we should remember that this model takes us back to the history of our cities. This exercise provides the basic techniques necessary to do a systematic investigation, which in the twenty-first century can now be done using a geographic information system. Remember that Louis Pasteur only completed his test of what we now call pasteurisation in 1862. Thus, Dr Snow was on his own.
Tools	B2.01, C2.01, C2.02, C2.05, C3.01, C5.01, C7.04
Case studies	Ethiopia: WASH Movement for better sanitation and hygiene (#335) Haiti: The Impacts of the 2010 Earthquake on Water and Sanitation in Port-au-Prince (#469)
Related material	To find out a bit more about the problems Dr Snow had to face, read: http://www.ph.ucla.edu/epi/snow/snowcricketarticle.html

Example lecture 12: Polluter pays principle in the water sector

Prerequisite	None
Duration	2–4 hours
Content	According to Pigou (in 1920), the polluter pays principle (PPP) was described as follows: "You may discharge any amount of pollution you wish, but your emissions will be measured and you will pay a tax for each unit of pollution." In other words, every actor is responsible for the real costs that are associated with the environmental impacts caused by his/her activities. The principle has its roots in the Organisation for Economic Cooperation and Development (OECD). It is a principle of economic policy wherein the person responsible for causing pollution should ultimately be held responsible for bearing the cost of pollution abatement or remedying the harm caused. This principle is, however, frequently misunderstood. The PPP as presented by the OECD is a principle that makes polluters pay the cost of preventing pollution before it occurs. But to pay the cost is different from bearing the cost. In the original PPP, 'pays' only means 'to pay'. Because potential polluters primarily pay the cost of preventing pollution, according to the PPP, that cost may be shifted upwards or downwards in the market.
Learning objective	This lecture aims to help students understand the evolution of the polluter pays principle and the difficulty of applying it in real life.
Methods	Four short videos are shown to illustrate both the evolution of the PPP and its various interpretations.
Videos	Hayek on the Polluter Pays Principle (1970) at https://www.youtube.com/watch?v=SMkQjIOxfmE (1 minute) Environmental Search (2011) at https://www.youtube.com/watch?v=h7GrxGycR1o (4 minutes) PPP Debated (2013) at https://www.youtube.com/watch?v=4HOzwZQoxX8 (9 minutes) The latest evolution in the definition of PPP (2015) at https://www.youtube.com/watch?v=Z9OCPqzbzBk (3 minutes)
Debate/ Discussion	After the videos, the students are divided into two groups to list advantages and disadvantages of PPP. Students might respond as follows: Some advantages include: ■ avoiding (mitigation of) externalities ■ transferring the cost of the pollution to the polluter and apportioning the cost of the pollution appropriately ■ generally reducing the overall level of pollution by acting as an incentive to save money and thereby reduce polluting activities. Disadvantages include: ■ it tends to create argument about what is pollution and what is not ■ deciding how much should be charged for a pollution impact ■ identifying who specifically is causing the pollution ■ it can be seen as inhibiting economic growth, particularly in less developed countries.

Debate/ Discussion	The lecture continues with a debate on the following questions: ▪ Why use economic tools and not prohibition of pollution activities? Why is the same logic not imposed in the case of heroin? ▪ Why not replace combustion plants (coal, gas, oil) causing enormous pollution with nuclear power plants (that do not emit pollutants into the air)? ▪ Why impose charges on polluting plants but not request automobile manufacturers to produce perfectly clean engines? On the specifics of water pollution: ▪ Should we charge for pollution that exceeds the limit or any unit of pollution?
Tools	C7
Case studies	Costa Rica: Environmentally Adjusted Levies for Water Use (#378)

Example lecture 13: Role play game – hypothetical situation of a shared river

Prerequisite	This example is a role play game designed for graduate students. There are no prerequisites.
Duration	Approximately 4 hours. This may vary due to introduction and conclusions by the lecturer.
Content	In a role play game with four groups, the hypothetical set-up of a transboundary basin is shared by three states. Three groups each act as one state to defend their positions and present a proposal on management and agreements. Each group should justify their proposals (i) based on the national interest (relevant factors) and (ii) in accordance with international principles and practices. All proposals should explain the legal basis: principles, norms, and international law doctrine. The fourth group serves as the mediator of any conflicts, aiming to produce an international agreement about the river's management. This role play game is an adaptation of the game originally proposed by Elisa Colom de Morán, GWP Central America and Pilar García, Universidad del Externado de Colombia, during the Workshop for Training Capacities on International Water Law (VII Taller de Capacitación sobre Derecho de Aguas Internacionales para la Cuenca Amazónica), 4–8 July 2016, Manaus, Brazil.
Learning objective	The learning objectives are (i) to understand the complexity of the governance of international waters; (ii) to understand the water-related benefits and harms between states in upstream–downstream and downstream–upstream conditions; and (iii) to identify the chain of processes that causes socio-environmental impacts.
Role play game method	The Coffee River is an international river shared by three riparian states. The river is born in the Coffee Mountain located in State A, flowing through State B before reaching the sea at the Coffee Delta, located entirely in the territory of State C. The watercourse flows through an arid area that suffers from water stress.
Introduction	There is no specific treaty among the countries, establishing how to use, handle, or environmentally protect the entire watercourse. Instead of a treaty, issues are addressed informally. Despite the lack of a general treaty about the Coffee River, all riparian States have adopted several declarations and resolutions promoting international cooperation in order to achieve reasonable, equitable, and sustainable development of shared water resources. However, all riparian States have ratified the UN Watercourses Convention.[20] The States also have an interest in learning about the experience from the United Nations Economic Commission for Europe (UNECE) Water Convention,[21] to consider adhering to it as it has been open to subscription for non-member states of UNECE since March 2016. Until the present time, the riparian States have reached a level of ad hoc cooperation on water resources, but the increased competition for the finite waters of the Coffee River is causing great stress, and there is general recognition of the need for a comprehensive treaty covering the waters of the entire basin. Attempts to get all riparian States to agree to a formal convention on an allocation scheme for uses of the water of the Coffee River are already under way.

[20] United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses (New York, 21 May 1997), which entered into force on 17 August 2014.

[21] Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992), which entered into force on 6 October 1996.

Group work

The students are divided into groups. The original activity was a role play game with four groups, where each of three groups defends one of the States' positions and presents a proposal, and the fourth group acts as the mediator of any conflicts, aiming to produce an international agreement on Coffee River management. Each State group should justify its proposal (i) based on the national interest (relevant factors) and (ii) in accordance with international principles and practices. All proposals should explain the legal basis: principles, norms, and international law doctrine.

In our variation on the class activity, we propose to focus on the geography of water and the recognition of socio-environmental impacts: each group should prepare a matrix of interaction, as an adaptation of the Leopold matrix. We suggest students put the three States in rows and columns, and in each intersection between row and column they should indicate what impacts (positive and negative) activities in one State could have on the other State. It is also possible that activities in one State will impact other regions of the same State. That is why in this activity the diagonal in the matrix cannot be null. An example of such a matrix is given below.

A hypothetical map of the Coffee River basin is needed to support spatial analysis and help understand the dynamic impacts upstream and downstream. Students are recommended to pay attention to the morphometry of the Coffee River basin and the Green River basin, the boundaries of States A, B, and C, biodiversity conservation and respect for cultural heritage, and the relationship between cultural heritage and physical aspects of the environment.

All groups should present their matrix of interaction and the map of the Coffee River basin, and compare and discuss the differences and complementary perceptions.

Additional information on the shared river role play game

State A

State A is sparsely populated and covers a large territorial area; despite having considerable oil reserves, it remains, economically, a developing country. Approximately 60 percent of the drainage area of the Coffee River basin is within the territory of State A, and this area contributes about 75 percent of the total flow of the river. State A recently unveiled plans to expand agricultural production massively through an irrigation system that aims to achieve food self-sufficiency and turn the country into an exporter of cotton (which is a particularly water-demanding crop). Over the years, State A has failed to develop its agricultural production due to unfavourable weather conditions and other factors, including poor soil quality, transportation infrastructure, and agricultural practices. For example, the cotton produced by State A rarely finds international markets because it fails to meet international quality standards. Large-scale irrigation has now increased salinisation of the water in the Coffee River due to the return of wastewater into the river, adversely affecting potential uses downstream.

Moreover, although State A has abundant energy resources (hydrocarbons), it has plans to develop a large-scale hydroelectric power station and export electricity throughout the region. However, it has been suggested that other riparian States downstream must pay a large proportion of the costs of building this infrastructure, as it will also facilitate inter-annual storage and water regulation.

State B

State B is highly populated and economically developed. It is the only one of the three States that has large reserves of groundwater, because the Coffee Aquifer is located entirely within its territory. The Coffee Aquifer is part of the hydrological system that includes the Coffee River. However, these groundwater resources have not yet been exploited due to lack of technical capabilities and infrastructure. It is generally considered that the development of underground water resources is costly and can only be achieved in the long term. State B is aware of the risk that new uses and planned projects upstream may adversely affect the quality and quantity of available water. A considerable number of its population are totally dependent on the water of the Coffee River for household use and subsistence farming. In addition, several indigenous communities living in State B have traditionally fished on Coffee Lake (fed almost entirely by the Coffee River) and they have also hunted in the wetlands surrounding the lake. State B has advanced plans to develop lucrative industries of ecological and cultural tourism in the region of Coffee Lake.

State B is rich in mineral resources and mining is one of the core activities of its economy. However, these activities have caused significant pollution of the Coffee River and have therefore limited the development of potential uses downstream. For several years, State B has expressed the intention to implement plans to introduce large-scale activities giving added value to mining processes and other industrial activities based on mineral assets. However, this requires the consumption of large amounts of water and would mean greater pollution of the Coffee River.

State C

State C is a populous state with a highly developed economy that relies almost exclusively on the water of the Coffee River. It has traditionally been the largest user of water from the Coffee River for domestic, agricultural, and industrial purposes (it represents approximately 60 percent of all water consumption derived from the Coffee River). Its territory occupies a small proportion of the total area of the drainage basin and, due to its arid climate, it hardly contributes any water to the river flow. However, its use of the water is widely recognised as very efficient, due to national legal requirements to use efficient technology, its pricing structures, and other measures to conserve water. State C is opposed to the increased upstream use of water from the Coffee River, based on the recognition that such a practice could conflict with existing uses and the delta of the Coffee River could be seriously affected: the flow that feeds a wetland of great beauty could diminish, and the wetland is internationally recognised for its importance for wildlife. Coffee River Delta is also an important source of tourism income for State C. To date, State C has resisted efforts to establish a common legal mechanism to manage the Coffee River.

State C now realises that it could become an agricultural producer and exporter if it substantially increases access to water for irrigation in the region of the Green Valley. This region is a fertile and sparsely populated territory, where traditionally the water of the Green River has not been sufficient. Therefore, it has prepared plans to transfer waters from the Coffee River and to build irrigation systems technology. These plans are central components of the economic development strategy of State C. State C intends to use its proximity to world markets and good trade relations with other countries to develop numerous agricultural industries that use water intensively. However, there are concerns about potential impacts on the biota of the fragile ecosystem of the Green River, which is shared between State C and State B.

Example matrix of negative and positive effects between states

	State A	State B	State C
State A	Building dam may cause flooding in upstream areas		
State B	Cotton crop could diminish water availability; building dam may impact river flow, with severe impact on traditional people and culture	Mining causes environmental impacts	Increasing irrigation in Green valley may impact the portion of the valley in State B
State C	Cotton crop may diminish water availability; building dam may impact river flow	Mining causes environmental impacts	Transfer of water from the Coffee River could impact estuarine biodiversity

Adapted by Carlos Saito from Computer-supported games and role plays in teaching water management.

CHAPTER 4. GUIDING QUESTIONS

Questions related to the natural environment and climate

1. Consider the water resources situation in your country (basin). Identify institutions/agencies in charge of water use services to individual sectors (agriculture, energy generation, industry, city, environment, etc.) with competing demands for water use. Discuss whose competing water demands are for preserving ecosystems. What powers and resources do these agencies (if they exist) have in comparison with other sectors? In the case of water shortage, who makes the environmental case?
2. How are water and climate change connected? How can changes in water supply due to climate change impact the different ecosystems in your city? Your country?
3. What does no/low regret adaptation measure to climate change mean? Give examples and explain the evaluation methods used to calculate adaptation measures/options that maybe suitable for a particular country to undertake to reduce the impacts of climate change.
4. What do 'blue water', 'green water', and 'grey water' refer to? Explain and list examples of each.

Questions related to water policy and law

1. Discuss the key differences of the UN Water Convention on the Law of Non-Navigational Uses of International Watercourses (1997) and national water law.
2. List the fundamental precepts of international water law.
3. What are the prerequisites of a good interstate cooperation and how are these applied within your country and its neighbouring countries?
4. In which ways can water use rights be acquired within national law systems?
5. What are the key water resource authorities in your basin, city, country? Is their sole purpose to provide guidance on water resources or do they also play a role in other sectors (agriculture, energy, forestry, etc.)?
6. What does 'integrated' mean in IWRM? What do we lack in water resources management when we remove 'integration'?
7. Select an urgent environmental problem in your country. Which policy instruments and measures are used to modify this problem/situation? To what extent do they reflect a certain strategy of influence (regulative, incentive, communicative, technical, etc.)? Have any of these changed over time or are they likely to change in the foreseeable future?

Questions related to social aspects

1. How does water contamination affect the food chain?
2. Water can be a primary cause of conflicts. What is the ultimate mechanism for conflict resolution?
3. List the values of water.
4. The central role of women in water management has been formally recognised since the International Conference on Water and the Environment in 1992. Are there any concrete examples of women taking on positions in governments that were previously male dominated? What were the outcomes?

Questions related to planning and decision-making

1. Find an example in your country of how an environmental group has influenced the direction of public policy. Discuss why (and if) the group was successful in their efforts. How could their strategy have been improved?
2. Suppose you come from a part of the world with an abundant water supply, where the available amount far exceeds the demand. Would you want your government to be cautious about the decisions it makes regarding water allocation?

Questions related to technical infrastructures

1. The Panama and Suez Canals were monumental water-related structures with local and global implications built more than 100 years ago. How would the application of IWRM principles have changed these projects?
2. Technical infrastructures vary in size. Which ToolBox management instruments are more likely to be used in promoting large infrastructure projects (e.g. large dams) versus small infrastructure projects (e.g. water harvesting systems for a small village)?
3. Technical innovations to reduce demand at domestic or agricultural scales are usually more expensive than traditional solutions. List five tools within the IWRM ToolBox that you consider most appropriate to promote new technical innovations at both the domestic and agricultural levels.
4. Wastewater treatment plants (WWTPs) reduce contamination in superficial water bodies. In most cases, WWTPs depend solely on public funding and their importance is as clearly visible as in the case of drinking water treatment plants. How do you think IWRM tools can promote the sustainability of WWTPs?
5. In recent years, the concept of water footprint has gained relevance. What would be the reduction in water consumption if your country or city lowered meat consumption by 50 percent? In terms of population, what would be the number of people who contribute to this water saving?

Questions related to economics

1. Pollution of water courses can be associated with run-off from agricultural land uses (diffuse pollution). It is difficult to determine exactly where the pollution originates and in what volumes. Assume the cause of pollution from agriculture farms is unknown. Given the lack of data, discuss which economic instruments could be used. Compare economic instruments with direct regulations in the case of diffuse pollution. Possible responses include: a charge for each unit of used pesticide/nutrient, and a farm subsidy for positive behaviour.
2. What are the preconditions of a well-functioning water pollution fee system? Possible responses: regular monitoring of pollution, transparent enforcement, inability of the polluter to transfer the cost to the consumer, establishing a high pollution charge for a limited number of toxic pollutants and sources, and a low pollution charge for all other pollutants and sources.

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