United Nations
Educational, Scientific and
Cultural Organization

United Nations Decade of Education for Sustainable Development (2005-2014)

International
Hydrological
Programme

Learning about Water -
Multiple-Perspective Approaches

Education for Sustainable Development in Action
Learning & Training Tools N°5 - 2012
UNESCO Education Sector

Learning about Water – Multiple-Perspective Approaches

U N E S C O

Education for Sustainable Development in Action
Learning & Training Tools N°5

2012

Published by the United Nations Educational,
Scientific and Cultural Organization
7, place de Fontenoy, 75732 Paris 07 SP, France

Developed in the context of the UNESCO Intersectoral Platform on Education for Sustainable Development by an intersectoral group of colleagues from the Education, Natural Sciences, Culture and Communication sectors, in collaboration with the International Hydrological Programme.

Initial draft prepared for UNESCO by Claudia Khourey-Bowers, Ph.D. - Kent State University (USA) and pilot tested through UNESCO Hanoi, UNESCO Kingston and UNESCO Windhoek.

Final draft prepared for UNESCO by Michelle Hollett - Columbia University (USA).

Main target audience for this tool: secondary school teachers

Education for Sustainable Development Section (ED/PSD/ESD)
UNESCO,
7 Place de Fontenoy,
75352 Paris 07 SP, France
email: esddecade@unesco.org
web: www.unesco.org/education/desd

Cover design: Helmut Langer

ED/PSD/ESD/2012/PI/2

Contents

I. A Multiple-Perspective Approach for ESD and Water

The Multiple-Perspective Tool is a valuable framework for teaching any sustainable development issue. The focus of this particular companion document is on applying multiple perspectives for Education for Sustainable Development (ESD) to freshwater issues. Water is an important resource for sustainable development and has been identified as a priority by the UNESCO Member States, among other emerging and recurrent issues. Water is crucial for all living organisms and ecosystems. In addition, water is essential for human health, food production and security, as well as for social and economic development. Political commitment, community action and many other factors including those influenced by cultural and academic disciplines signal the multiple-perspective value of water. As concluded in the UN World Water Development Reports, the looming water crisis, more than a result of the availability of the resource, is a result of existing water governance approaches (Intersectoral Platform, 2010). Water, more so than any other natural resource, except for the air we breathe, is a shared resource, uniting people, communities and habitats across vast expanses of space and time. As water flows through one catchment area and into another, or evaporates into the atmosphere to be whisked by jet streams across continents, it carries traces of its travels around and through the globe. The quality of water and the rate of its recharge are reflections of the diversity of human actions and interactions with the resource. To educate for sustainability of water, we must also educate about how water is used, valued, governed and reserved throughout the world.

Teaching through a multiple-perspective approach provides a valuable means to guide holistic thinking about complex systems, most specifically about environmental issues. A multiple-perspective approach conveys the dynamic parts-to-whole relationship, which constitutes complex systems such as the Earth's freshwater system. The many processes and events of both natural and human influences on freshwater systems become accessible and meaningful to learners. Students are guided to understanding through seven unique, but overlapping, perspectives on the relationships within natural systems and between natural systems and human society.

The Multiple-Perspective Tool can be used as a pathway to:

- learn about sustainability issues from multiple bodies of knowledge,
- identify and understand personal and others' perspectives, and
- apply decision-making processes to complex issues that affect personal, community, and global well-being.

Complex issues related to water sustainability entail geographic, political, scientific, cultural, economic and social factors. By its very nature, teaching for water sustainability requires that multiple perspectives be applied when searching for solutions or good practices in water management. Individual students who have experienced a multiple-perspective approach have more opportunities to establish a sense of place, both in their local and global communities. Through local action and understanding the perspectives of others, students can better know themselves.

II. Using the Multiple-Perspective Approach for ESD and Water

1. Why Use Multiple Perspectives for ESD and Water?

As stated in the resolution launching the DESD, "education is an indispensable element for achieving sustainable development" (United Nations, 2002, p. 1). This is particularly true for water sustainability. Every year millions of people are severely affected by poor water quality, scarcity and floods. Several billion lack access to safe drinking water and improved sanitation. There is a growing consensus that the water crisis is largely due to limitations in the way water is used rather than the mere scarcity of the resource (WWAP, 2006). The need to strengthen water education at all levels – informal, formal and non-formal – continues to receive increased attention in international initiatives.

2. Suggested Multiple-Perspective Instructional Strategies for ESD and Water

In this section, suggested instructional strategies and related Multiple Perspective questions, specifically designed for ESD teaching and learning about water, are provided. These examples are intended to be starting points for adaptation into specific classroom topics and communities. All of the strategies have been designed to build knowledge, skills and attitudes consistent with teaching and learning for ESD.

2.1 Scientific Perspective

What does learning about water through a scientific perspective mean?

A scientific perspective is based in collecting, analyzing, and interpreting empirical data about natural cycles and phenomena, understanding the dynamic equilibrium across biotic and abiotic components of the Earth, and applying empirical knowledge to solve problems.

A scientific perspective is assumed to be context-free, such that consideration of the other perspectives documented through the Multiple-Perspective approach would have no effect on the data or data analysis of a strictly scientific perspective. The scientific perspective maintains that scientific knowledge is "true" and useful in any setting.

Suggested Instructional strategies for learning about water through a scientific perspective:

Strategy 1. Students can assess local water quality conditions, including acidity and salinity, and then use the processes of clarification, disinfection, and distillation to improve water quality. As students share their data with the data collected from students in other parts of the world, they will begin to understand the usefulness of scientific procedures and communication in assessing water quality issues. (For access to this set of four experiments, refer to International Year of Chemistry in the Resources section.)

Sample Questions: How much variation in local water conditions did you find? How can you account for the variations? How much variation exists in water quality conditions, as seen through your participation in the data from the Global Experiment? What are some of the factors that account for the variation? What variables could you manipulate to change the data in your local water sites? Why are three stages used to purify water? How can comparisons of data collected in different places and in different times help us analyze and maintain water quality?

Strategy 2. Students can create models of the water cycle, using local topography as the images to represent the important processes of evapo-transpiration, condensation, precipitation, surface water run-off and groundwater flow. Through the model of the water cycle, students should become more aware that water is a renewable resource due its relatively short residence time in most phases. However, if surface water or groundwater is drawn in

amounts which exceed the capacity of the stream or aquifer to be replenished within a particular time frame, these practices become non-sustainable.

Sample Questions: How can changes in weather patterns affect water availability for domestic use, irrigation, and industrial use? What is the significance of variations in the residence time of water in various phases of the water cycle? How do extreme weather conditions in distant parts of the world affect local weather patterns and events? How can consumption and discharge patterns in local catchment areas affect the regional catchment area? How can thinking about the catchment system as a whole help engineers and scientists make better decisions about water management?

2.2 Historical Perspective

What does learning about water through a historical perspective mean?

Learning about water through a historical perspective helps learners understand how natural or human-created water issues have been addressed over extended periods of time, as well as in the present. Learners should analyze responses to water issues within the context of available knowledge, technology, perceptions, or cultural expectations. Using evidence from past and current situations, learners should understand how local and global communities have made water management decisions and the implications of those decisions.

Suggested instructional strategies for learning about water through a historical perspective:

Strategy 1. Students can create multiple-tier timelines (chronologies) of significant water events (floods, droughts, hurricanes, pollutions) over the last fifty or hundred years.

Sample Questions: Is there a pattern of water-related events or phenomena that affects quality of life? Have water management decisions in a particular catchment area been consistent over an extended period of time? What have been some long-term effects of past decisions? Has the frequency of significant water events changed over the last 50 years?

Strategy 2. Using the multiple-tier timeline as a starting point, students will conduct research (e.g. from Internet sites, weather records, newspapers, and textbooks) on major water events. They will also interview community members about their memories of weather events during their lifetimes. Students will also ask people if the community has become better prepared to handle extreme water events than in the past. For events that occurred during the lives of interviewed community members, students can document the differences between peoples' personal histories and formal histories of the events. Students will analyze how the community at large has adapted to water extremes, either through technology or changes in practices.

Sample Questions: How consistent are anecdotal accounts of major events from person to person, in comparison to written documents? Have water management decisions in a community been consistent over an extended period of time? How have changes in leadership and governance affected management and distribution of water supplies?

2.3 Geographic Perspective

What does learning about water through a geographic perspective mean?

Learning about water through a geographic perspective helps learners understand how natural or human-created water issues appear and perhaps reoccur across a community, region, country, continent or Earth. Events (natural and human-caused) or challenges take on different complexities when examined at a local scale, national scale or international scale. For example, if students are studying about water pollution the problem may be isolated to one well or it could extend across an entire aquifer. Similarly, the problem may appear as a pattern (e.g., in agricultural valleys that use

chemical pesticides or in areas with insufficient sanitation). By studying the geographic scale and recurrence of a problem, students gain deeper insights into the origin of the problem and potential solutions.

Suggested instructional strategies for learning about water through a geographic perspective:

Strategy 1. Students can use topographic maps to study a water event or challenge. Students can use the maps to outline the watershed in which they live. Then, the students can mark the location of each problem (e.g., contaminated wells in their community). They can map the location of various types of problem on the same map using symbols to differentiate the types of problems (a blue star for a clean well and a red star for a contaminated well as well as a black star for dry wells). Then students should look for patterns in the symbols. Topographical differences and similarities may help student understand patterns. For example, wells located downhill from sanitary facilities may be contaminated. The students may need to visit locations on the map to learn about the sites and then do their analyses.

Strategy 2. Students can map information from a database thereby changing tables of numeric information into more easily visualized maps. The students can request a water-related database from the government. Then can create a choropleth (color block) map from the information. They will need a base map with the same geographic divisions as the data. For example, both the data and the base map should be at the district (e.g., sub provincial level). The students will experiment to with different divisions of the data, such as quartiles 0 – 2.49, 2.5 – 4.99, 5.0 – 7.49 and 7.5 – 10.0). The various attempts to create a key will greatly affect the appearance of the map. Students can discuss which data divisions would be most effective in conveying the information.

Sample Questions: Has the water-related event or challenged changed in size recently (e.g., was it small previously and is now large)? Is it predicted to increase in size? Can you identify a pattern to the event or challenge (e.g., it is found in valleys and not on ridge tops). Does an adjacent community have the same water-related event or challenge? Are communities on other continents also affected by this water-related event or challenge? How does the map convey or distort the information presented?

2.4 Human Rights Perspective

What does learning about water through a human rights perspective mean?

A human rights perspective stresses the relationship between access to sufficient supplies of safe water and opportunities to access other universal rights, notably education, health, and active participation in governance. Learners should understand how natural distribution patterns of water may affect access to safe water, how water practices may improve or worsen a group's opportunities to fully participate in other universal rights, and how financial resources of individuals or communities may affect the impact of natural or human-made water issues.

Learning how natural distribution patterns of water, as well as availability of human and institutional capacities, adequate governance, financing and infrastructure, may affect access to water. In addition, a human rights perspective teaches about the effects of water quantity and quality on other aspects of quality of life. This requires that water is understood not as a purely economic good, but also as a social and cultural good.

Suggested instructional strategies for learning about water through a human rights perspective:

Strategy 1. Students would study regional maps and demographic data to learn about the prevalence of water-related diseases among poor populations, often related to inadequate capacities

and supplies, disasters (e.g. floods), or conflicts (intentional or unintentional disruption or destruction of infrastructure).

Sample Questions: How can water quality be improved to make it safe for drinking? How do chronic malnutrition and disease affect a community's ability to provide a good quality of life for its members? How can improved human capacities (e.g. via education) and infrastructure (e.g. wells, water treatment facilities) improve the quality of life for all? What are the social, economic and environmental implications of the right to water? How is it related to other human rights, including the right to education?

Strategy 2. Students would engage in discussions in which diverse peoples' needs and goals are represented in an effort to understand how different human rights are interrelated.

Sample Questions: Do certain groups within the population have more to gain with improved water and sanitation? What are the implications for other facets of water quality? How does limited access to water affect people's ability to fully participate in educational, economic, cultural, and other aspects of society? What are the potential effects, in a population, of limited civic participation?

2.5 Gender Equality Perspective

What does learning about water through a gender equality perspective mean?

During the learning process, learners explore how social and cultural practices regarding access and use of drinking water and household water may affect men and women differently, including gender roles in water decision-making at different levels, in water harvesting and water uses in different communities.

Learners can also consider how access and long-standing practices related to water resources, especially for domestic use, may have contributed to unexamined consequences of traditional gender roles, including differential access to education and work opportunities. Students may consider, too, how advances in water management (e.g. technology) may have changed the context for traditional water-related gender roles (e.g. technology has replaced the need for physical strength in completing many tasks).

Suggested Instructional strategies for learning about water through a gender equality perspective:

Strategy 1. In some regions, women and girls have gender-specific responsibilities for collecting water, which can take several hours each day. In part due to these water practices, girls' ability to attend school and become literate, a key factor in establishing a good quality of life, is differently accessible to them than to boys. Learners should speculate on ways to make safe water more easily accessible to all members of the community, as well as on ways to create more equal opportunities for education and literacy.

Sample Questions: Why might rates of poverty and illiteracy be greater among women than among men? How can water-related practices affect peoples' access to education and other avenues of economic success? How can water-related practices be shared more equitably among members of the community? What alternatives may exist for balancing access to water and access to education?

Strategy 2. Students will research how accepted habits of providing drinking water affect participation in various aspects of community life, including school, commerce, and governance. Students will document daily tasks of their own family members, over an extended period of time (perhaps two weeks). Students would then aggregate the data with those of their classmates, to look for gender-related work patterns.

Sample Questions: What lifestyle or societal practices does one gender practice that may diminish their ability to have equal access to resources? How much flexibility exists in a particular community for people to go beyond accepted gender roles? Can assumptions about gender roles limit peoples' contributions to society? Are water related practices in the community gender sensitive?

2.6 Values Perspective

What does learning about water through a values perspective mean?

Learners understand how particular needs or perspectives that an individual or group holds can dominate their ideas on water sustainability. Learners should recognize that participatory discussions about water access or usage should seek understanding across different values, with the goal of finding a consensus position or action.

Suggested instructional strategies for learning about water through a values perspective:

Strategy 1. Students should be read a series of statements on water management issues. As each question is read, students can indicate the degree to which they agree or disagree with the statement. After students have responded independently to each question, they can discuss their opinions with small groups of fellow students. Students should be guided to explain their positions and to ask their classmates why they feel they way they do.

Sample Questions: Did you see a pattern in your responses? How would you describe your values in regard to water as a resource? As you listened to your classmates explain their responses, did you change any of your opinions? What did you learn from listening to others' explanations?

Strategy 2. Students can participate in a town council regarding local water usage. For information on the instructional strategy of a town council, see Additional Resources section in the Multiple-Perspective Tool on Structured Academic Controversy. Students can first document the values perspective of each speaker, then, using a graphic organizer (such as a Venn diagram) make connections about which values are mutually supportive and which seem to be mutually exclusive. Finally, students can suggest possible solutions which acknowledge and respect the values expressed during the town council meeting, in an attempt to move the community toward a common course of action.

Sample Questions: What diverse values are evident among the local community? Which value systems are most consistent with collaborative approaches to problem-solving? Do the different value systems indicate a worldview where humans are seen as stewards or consumers of natural resources? How can differing value systems be respected, while finding a single solution to a regional water concern?

2.7 Cultural Diversity Perspective

What does learning about water through a cultural diversity perspective mean?

Learners understand that water issues may be interpreted through unique worldviews that are created through aesthetic, empirical, or transcendent ways of knowing. A cultural perspective is often a unique perception associated with a particular community, which may serve to separate that community from other cultural communities. A cultural diversity perspective considers the role of water in the cultural community's worldview.

Suggested instructional strategies for learning about water about water through a cultural diversity perspective:

Strategy 1. Students may use primary sources from several distinctive cultures (e.g. where water is scarce or plentiful; rural societies and industrial ones) to understand the values attributed

to water in societies. Primary sources can include oral and written stories, songs, poetry, and other forms of cultural expressions. Students can then compare and contrast the underlying values as expressed through the primary sources to interpret each culture's assumptions and values regarding water, as a part of their worldview, a resource, etc. If combined with a historical perspective, such comparisons may also be made within one given society, at different periods of time.

Sample Questions: What contributions of unique cultural groups have affected water resources? What cultural traditions are symbolic of the role of water in people's lives? What values regarding water do customary practices convey?

Strategy 2. Students will consider water-related issues which embody a moral or ethical dilemma. Students will take part in a town hall -style discussion, in which groups of students impartially take on distinct roles, including religious and/or moral. One dilemma is that of the potential mining of Jesse Morrow Mountain, in California, U.S.A. (http://kingsriverlife.com/08/21/the-jesse-morrow-mountain-project/).The mountain marks the gateway to Sequoia and Kings Canyon National Parks and stands as a sacred landmark to the traditional Choinumni people. Cemex, one of the world‘s largest cement manufacturers, has asked approval from the local county government board in Fresno County to open a mine and reclamation project site on Jesse Morrow Mountain.

Sample Questions: Should economic development be pursued in areas that many believe to have religious significance? If the mining permit is granted, what are the implications for respect of diverse religious beliefs? If the mining permit is denied, what are the implications for economic development in other areas?

2.8 Sustainability Perspective

What does learning about water through a sustainability perspective mean?

Learners consider the interactions between the environment, economics, and society to ensure an adequate supply of safe water for ecosystems and people today and for future generations.

Quality of life issues should be considered in the context of natural and human-made resources. All societies need access to safe and adequate water resources to maintain a quality of life consistent with universal human rights. Projected needs of future generations should also be considered, with planning for future use and growth as integral components of sustainability decisions.

Suggested Instructional strategies for learning about water through a sustainability perspective:

Strategy 1. Students can draw a map showing land use patterns in the local catchment area. Types of land use include residential, agricultural, industrial, and recreational. Students should then indicate on the map how each type of land use may affect water quality, access, and distribution. Students should then interpret how different uses of land and water resources affect overall environmental quality, economic development, and quality of life.

Sample Questions: How can surface water and ground water be used for economic development with minimal degradation to the ecosystem? How do activities in one section of the catchment area affect water quality in other sections? What kinds of actions can people take to maintain the quality of natural resources while developing economic resources?

Strategy 2. Students can research animal husbandry and farming practices which have the potential to minimize non-point pollution of surface water run-off. In this study, students should incorporate issues from economic, environmental, and societal aspects. Students can interview leaders in the agricultural community to learn specific farming practices that

can reduce costs and increase productivity. Students should then communicate what they have learned to community members through brochures, radio programs, or meetings.

Sample Questions: How can natural water purification processes be used in conjunction with human water purification systems? How can plantings, rain gardens, aeration ponds, and wetlands be used supplement the natural water cycle? What other kinds of structures can be included in the design of human-made development areas, such as farms, residences, urban centres, and industrial centres, to minimize degradation of water quality? What natural resources could be used to improve the economic development of the region?

III. Sample Lesson Plans

1. Water Documentary Viewed Through Multiple Perspectives

DESCRIPTION: In this activity, students will share a common experience by watching the same documentary focused on water. However, they will view the film from different perspectives and share their insights, giving the entire class a multiple-perspective assessment of the issue.

TEACHING TECHNIQUES: film/media, "jigsaw" cooperative learning, class discussion

OBJECTIVE: To learn about water from various perspectives through the use of media

MATERIALS: Documentary (from provided list in Resources section); worksheets of questions for various perspectives

TIME: 60-90 minutes

TEACHING SEQUENCE:

- Divide the class into 3-8 groups of equal numbers of students. Assign each group a different perspective (e.g. values, historical, sustainability, etc.).
- Distribute to each student a worksheet that pertains to his/her assigned perspective.
- Explain to the students that, as they watch the documentary, they should individually respond to the questions on the worksheet based on their assigned perspective.
- Watch the documentary.
- At the end of the film, allow students 5-10 additional minutes to complete their worksheets individually.
- Instruct students to form groups with the others from the same perspective – their "home" groups. Allow the groups 10-15 minutes to discuss their findings and compare responses. Encourage students to talk about what surprised them and what concerned them in the documentary, based on their perspective.
- Discussion questions for the single-perspective "home" groups:
  - How is water presented in the documentary?
  - How is water viewed through your assigned perspective?
  - What did the documentary address regarding your perspective?
  - What was left out?
  - What changes would you suggest to the filmmakers?
- Divide students into new "expert" groups where one representative from each "home" group is present. This can be done by assigning each student in the "home" group with a number and then designating a location in the classroom for all of the "1s" to gather and all of the "2s" to gather, etc. In these "expert" groups, allow 10-15 minutes for further discussion and comparison.
- Discussion questions for the mixed-perspective "expert" groups:
  - What was the primary goal of this documentary?
  - Which perspective was the most clearly addressed in this documentary?
  - How does the role of water change or vary depending on the perspective used?
  - Were there any perspectives that were not considered?
  - What did you learn about water? About the multiple perspectives?
  - What would you change?
  - What concerns do you have watching this documentary from your perspective?
- A discussion with the entire class can follow if necessary.

CLOSURE: How has this documentary changed *your* personal perspective of water?

EVALUATION: Listen to the responses of the group discussions and the closure, which can also be a written assignment to leave time for reflection. The answers are revealing of student understanding.

EXTENSION: Ask students to design their own documentary about water. What would they include? Who would they interview? What images would they show? Who would be the intended audience? What perspectives would they include and why? How would their documentaries differ from the one they just watched in class?

SOURCE: Saskatoon Public Schools. 2009. What is Jigsaw? *Instructional Strategies Online*. http://olc.spsd.sk.ca/de/pd/instr/strats/jigsaw/index.html

2. Water Case Study Explored Through Multiple Perspectives

DESCRIPTION: In this activity, all students will read the same case study focusing on a particular water topic. They will analyze the case study through the lens of a specific perspective. Students will then share their findings with their peers. This activity allows for the investigation of an issue at various levels and from various points of view.

TEACHING TECHNIQUES: Case studies, reading comprehension, "jigsaw" cooperative learning, class discussion

OBJECTIVE: To learn about water from various perspectives through the use of case studies

MATERIALS: Case study (from provided list in Sample Case Studies section); worksheets of questions for various perspectives

TIME: 45-60 minutes

TEACHING SEQUENCE:

- Divide the class into 3-8 groups of equal numbers of students. Assign each group a different perspective (e.g. values, historical, sustainability, etc.).
- Distribute to each student a worksheet that pertain to his/her assigned perspective.
- Explain to the students that, as they review the case study, they should individually respond to the questions on the worksheet based on their assigned perspective.
- Distribute and read the selected case study. This can be done in a number of ways: 1) teacher reads out loud while students follow along with their own copies; 2) students read individually; 3) students read in small groups; 4) students take turns reading out loud.
- After an initial reading of the case study, allow students 15-20 additional minutes to review the case study again and complete their worksheets individually.
- Instruct students to form groups with the others assigned the same perspective – their "home" groups. Allow the groups 10-15 minutes to discuss their findings and compare responses. Encourage students to talk about what surprised them and what concerned them in the case study, based on their perspective.
- Discussion questions for the single-perspective "home" groups:
  - What is the role of water in the case study?
  - How is water portrayed through your assigned perspective?
  - What did the case study address regarding your perspective?
  - What was left out?
  - What would you change?
- Divide students into new "expert" groups where one representative from each "home" group is present. This can be done by assigning each student in the "home" group with a number and then designating a location in the classroom for all of the "1s" to gather and all of the "2s" to gather, etc. In these "expert" groups, allow 10-15 minutes for further discussion and comparison.
- Discussion questions for the mixed-perspective "expert" groups:
  - Which perspective was the most clearly addressed in the case study?
  - How does the role of water change or vary depending on the perspective used?
  - Were there any perspectives that were not considered?
  - What did you learn about water? About the multiple perspectives?
  - What would you change?
  - Do you have any concerns about this case study based on your perspective?
- A discussion with the entire class can follow if necessary.

CLOSURE: How has this case study informed you and changed *your* perspective of water?

EVALUATION: Listen to the responses of the group discussions and the closure, which can also be a written assignment to leave time for reflection. The answers are revealing of student understanding.

EXTENSION: Encourage students to write a case study about a water issue in their own community or a community that they research. What elements would be important to include? How much background information is required? Who is the intended audience? What is the issue they are trying to convey? How do multiple perspectives play a role?

SOURCE: Saskatoon Public Schools. 2009. What is Jigsaw? *Instructional Strategies Online*. http://olc.spsd.sk.ca/de/pd/instr/strats/jigsaw/index.html

3. Local Problem, Global Impact: A Community Project on Water

DESCRIPTION: Relevance to students' personal experiences is considered one of the key elements of learning. In order to make global issues more meaningful and understandable to students, this project will use a community water issue to delve deeper into what the resource means on a local and global level, investigated through a variety of perspectives. Using their own community as a case study will help students fully grasp the concept of water.

TEACHING TECHNIQUES: hands-on, interviews/inquiry, research, class discussion, brainstorm

OBJECTIVE: To understand a local water issue and to utilize a variety of research methods to determine how water impacts the community.

MATERIALS: variable, depends on each group

TIME: variable; up to 2 weeks

TEACHING SEQUENCE:

- Explain to the students that they will be working on a multi-day project that focuses on their own community. This project will be selected and designed by the students; however, the project must be related to water and the research activities must utilize the multiple perspectives.
- Lead the students in a brainstorming activity to help them begin formulating ideas about a potential project topic. As a whole class, encourage students to suggest ideas of water-related topics that they have observed or experienced in their community. Write their ideas on a blackboard or piece of paper. If students need more time to think, give them the assignment to go home and talk with their families about other ideas.
- Once a lengthy list has been produced, discuss with the class the feasibility of the various ideas, ruling out the ones that would require too much time, are unsafe, etc. Consider rating topics according to the importance of each to the community. Vote as a class for the top project idea to pursue.
- When a project has been chosen, begin coordinating tasks. Assign students to small groups that will each take on a research assignment related to the water topic, focusing on a particular perspective. Each group will be responsible for 1) defining the questions that they would like answered and 2) developing a method by which they obtain the necessary information. Potential group task ideas:
  - Scientific: Research (via library and/or data collection) and compile information about the water topic. What is happening to the environment, people and economy because of it? What are the implications for the community?
  - Historical: Research the water topic in books, newspapers, online, at the local Historical Society, etc. Determine how the issue has progressed and how the community has responded.
  - Geographic: Visit the site of the water issue if possible. Using a contour map as a base, draw a detailed map of the watershed, highlighting key features. Students could meet with the Town Planner or another member of the community who knows the water topic well. Have there been any other regions around the world that have experienced a similar issue?
  - Human Rights: Research water rights and town policies. Speak with a local lawyer about the water topic and learn about what this means for the community members.
  - Gender Equality: Interview men, women and children who live by or are affected by the water issue. What do they experience? What has changed? What would they like to see happen?
  - Values: Survey the community members at large to determine how important water is to them compared to other resources.
  - Cultural Diversity: Interview community members of different ethnic backgrounds about their water use and beliefs. Write short stories about each person interviewed. Do different

ethnic groups in the community use water differently? Do different ethnic groups in the community perceive or celebrate water in different ways?
    - Sustainability: Think strategically about the impact and consequences of this water issue on the community. What are the major risks and consequences to the natural environment? What are the major risks and the consequences to human systems? What are the economic implications? What are the major currently implemented or proposed solutions? What are the obstacles to these solutions?
- Assign students a deadline for completing a report about their findings. (in-class time will be needed over the course of the project), When students have completed their respective assignments, the small groups can report to the entire class. The reports, depending on their assignments, can be in multiple forms – oral (e.g. radio reports), written (e.g. newspapers articles), maps, murals, etc.
- Allow each group to present its final report to the rest of the class.
- As a class, discuss what all of the pieces mean when they are brought together.
- Discussion questions:
    - How is this water issue affecting the community as a whole and parts of the community?
    - What has changed over the years?
    - What are the potential implications if nothing is done to correct the problem?
    - What are your recommendations for this community water issue?
    - How does this impact the communities around yours? The country? The world?

CLOSURE: Students should write a reflection of their experience throughout this community project. Some potential questions to consider: What have you learned about your community and its water use? Where did you learn the most information? Were you surprised by any information sources? What is a change you can make or have made in your daily life to lessen the issue? Beyond changes in your daily life, what is the next step you could take to address the issue?

EVALUATION: Review the group reports, presentations and the closure reflection writing activity. Listening to the group discussions and holding group meetings over the course of the project are also tools for assessing student understanding.

EXTENSION: Assist the class in drafting one final report based on the findings of each smaller group. With this final report, include the students' recommendations of steps to take to correct or improve the issue. Schedule an appointment with the appropriate town official so that the students can present their report.

SAFETY: All interviews, trips and ideas should be discussed with the teacher beforehand to ensure safety and legality. It is recommended that the teacher have regular meetings with each small group periodically throughout the course of the project.

IV. Sample Case Studies

Four case studies of global water sustainability issues have been developed from World Water Assessment Programme case studies (http://www.unesco.org/water/wwap/case_studies/index.shtml) and other sources.

Each case study has a challenge problem for students to attempt to resolve and discussion questions from each of the perspectives. While these case studies may prove to be useful in generating critical thinking, they too are considered a starting point for the teacher to design locally relevant Problem-based Learning and Place-based Learning scenarios.

1. Zambia Case Study

Introduction

Zambia is a country rich in natural and cultural resources. Located on the high plateau of Central Africa, at an average altitude of 1,200 m, Zambia has a mild, subtropical climate, with between 600 mm and 1200 mm of rainfall each year. The two river basins, the Zambezi and the Congo, have been important in shaping the natural ecosystems of Zambia as well as many cultural traditions.

The Zambezi, Africa's fourth longest river, runs a distance of over 3, 500 km to the Indian Ocean. The Zambezi Basin, shared by eight countries, is home to the greatest number of unique plant species in the world.

In the Barotse landscape of south-eastern Zambia, the Kuomboka ceremony of the Bembas has been an annual event. The term, Kuomboka, means 'emerging out of the waters'. When the plains are fully flooded every rainy season, the Litunga (King) and all plain dwellers sail in a colourful ceremony accompanied by an orchestra of traditional music and dance all the way to the highlands in Limulunga.

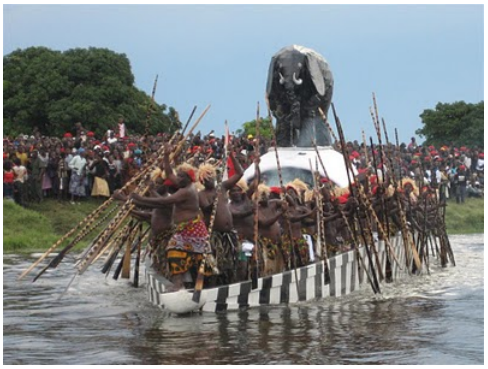

Photo from http://chadinzambia.blogspot.com/2007/04/07-kuomboka-time.html

The Zambezi and Congo river basins provide Zambia with an abundant supply of water for transportation, industry, hydro-power, cultural, and domestic uses. But the rivers have also been sources of illness, flooding, and physical obstacles to human and ecological well-being. Continued economic growth and improved quality of life in Zambia are dependent on wise and innovative uses of both surface water and groundwater. Collaboration with the neighbouring country of Zimbabwe, through the Zambezi River Authority and the Zambezi Watercourses Commission, can help to ensure that catchment run-off carries minimal levels of natural and anthropogenic pollutants.

Domestic Uses of Water

Water for drinking and other domestic uses, such as bathing, laundry, and washing dishes, comes mostly from surface water supplies. According to the World Health Organization about 90% of all Zambians have access to improved drinking water, while roughly 55% have access to improved sanitation. In the cities of Zambia, where about 40% of the population lives, most residents have access to improved drinking water and sanitation systems. For those people living in rural and periurban communities, improved drinking water and sanitary systems are much less common. Many people in rural areas use a traditional water source known as a scoop hole. The holes are located near a river, usually a kilometre or more from the village. Members of the community dig a hole, then water flows in though small openings in the clay which lies beneath the surface. Over time scoop holes can become very large and deep. People place logs across the scoop holes and stand on them as they draw water.

Women and children spend a good part of the day carrying water back home in 22-liter containers. The water from the scoop hole usually looks clear. If the water becomes cloudy or stagnant, men and women work together to re-dig the hole. During the dry weather, people draw water from the river itself because the scoop holes tend to dry out.

Water is important not just for basic needs, but also for social gatherings, celebrations, and entertainment. Zambians traditionally use bare hands when eating *nshima*, a traditional dish. Until 2004, the custom was that all the diners first washed their hands from a dish of clean water. In 2004, the Ministry of Health introduced a more hygienic system of hand washing, called D-Washa. The modified custom is that the guests, elders, older adults, younger people and children wash their hands in that order. The youngest person or the host, will pour water from a pitcher or water jug so that a diner will wash both their hands thoroughly with soap and let the dirty water drop or collect in a dish. The same procedure is followed once the meal is completed. The dirty water is then discarded.

Zambians often drink *katubi*, made from millet and water, during ceremonies and social gatherings. People will begin making *katubi* weeks before the special event in order to have enough for the party.

Entertainment for children includes swimming in the rivers during the dry season. At this same time, the scoop holes dry out too, so as children are swimming, women are gathering drinking water from the river.

Relationship between Natural Ecosystems and Catchment areas

Surface water (rivers and streams) are naturally protected by the vegetative cover of the forests in the catchment areas. Catchment areas can ensure that there is perennial water in rivers and streams, ensuring irrigation, hydro-electricity, domestic and industrial consumption. Catchment areas can earn the country millions of US Dollars in the form of hydro-electric power and water tariffs, industrial/agro-products and services and creation of employment. However, despite both the natural protection and legal protection of catchment areas under Zambian law *(Forests Act, CAP 199 of the Laws of Zambia)*, deforestation in Zambia has been advancing at a rate of 3,000 km^2 per year. It has resulted in localized flooding, increased erosion, reduction in surface and groundwater availability and loss of aquatic life (http://www.fao.org/docrep/003/X6701E/X6701E07.htm).

Effects of Industrial Demands and Hydro-Power on Water Supply and Quality

Copper mining, an important source of economic development in Zambia, can affect water quality and ecosystems. As part of the mining process, water is pumped from the mines and into local streams and rivers. This in turn can cause environmental degradation and reduced water quality. For example, Konkola Copper Mine discharges about 300,000 m3 of water per day into the Kafue River. Although there are some positive effects from mine discharges of water, such as making more water available for downstream users, these effects have not yet received much attention. The Kafue is an important source of water for many other economic activities for over 40% of the population. The Copperbelt Environment Project has been addressing environmental consequences of mining. In addition to the effects on surface water and ecosystems, the effects of mine pumping on groundwater have not yet been studied in detail. (WWRD3)

Hydro-electric power accounts for about 94% of water usage in the country. This high percentage is due in part to limited industrial use and to the fact that most agriculture is rain-fed, not irrigated. However, as demand for hydro-electric power increases as industrial capacity increases, the water supply could become a limiting factor.

Water use and sanitation is regulated at national and local levels. The 1997 Water Supply and Sanitation Act obliged local authorities to provide water and sanitation services using various arrangements, such as partnerships with private firms, concessions, and management contracts. Governments have also created organizations known as Commercially Viable Water Supply and Sanitation Utilities, or CUs. These partnerships must undergo testing to be licensed by the regulator, the National Water Supply and Sanitation Council (NWASCO). CUs are expected to meet private sector standards and to be self-supporting. The CUs have made significant progress even though government investment in water and sanitation infrastructure has been limited. Although performance and quality of service had been on a downwards trend, today an upwards trend is evident in a number of service indicators.

Concerns

Health, sanitation, and solid waste management are major concerns. Waste collection and management are inadequate, posing a serious threat to groundwater quality, particularly in periurban and rural areas, where between 40% and 80% of the urban population lives.

Malnutrition affects 46% of Zambians, mostly children. Water-related diseases such as malaria and diarrhoea are major health problems in Zambia. Nearly 4 million clinical cases of malaria are documented each year, with 50,000 deaths per year. Malaria alone accounts for up to 20% of maternal mortality and 23% of all deaths. Zambia has also been affected by HIV and AIDS, with about 9% of the population HIV positive (2000). The 2008 Health Survey indicated that HIV and AIDS affects 14% of people aged 15 to 49, the country's prime workforce.

Poverty and Environmental Degradation In addition to water borne diseases, environmental problems contribute to widespread poverty. Zambia is among the world's least developed countries, ranked by the United Nations Development Programme as 163rd out of 179 countries on the Human Development Index. Decreasing surface and groundwater quality, due to an increasing nutrient load, industrial and agricultural pollutants and a falling groundwater table, is a growing problem in highly populated urban areas. Environmental degradation, affecting forests, wildlife and fish populations, hurts the livelihoods of the poor, who depend the most on these resources.

The Challenge

Zambia is a country with enough water and land resources to facilitate economic development and enhanced quality of life. A limited infrastructure, even in the context of participatory governance, seriously impairs the country's ability to address many challenges, most notably poverty and hunger. Increasing the share of the population with access to safe water and improved sanitation, especially for people living in periurban and rural settings, would help curb the spread of preventable diseases that claim too many lives and reduce productivity. How can poverty and malnutrition be alleviated, while assuring sustainable socio-economic development and preserving a healthy ecosystem?

Suggested Discussion Questions for a Multiple Perspective Analysis of the Case Study

Values perspective: Why do you suppose hospitality and socialization are important values in Zambia? What kinds of practices involve water?

Historical perspective: Why are there laws to protect the catchment areas? What kinds of protection should the catchment area have? How can natural areas that span more than one nation or state be subject to one nation's laws? What other information would be helpful?

Cultural Diversity perspective: What cultural values does the Bembas' tradition of the kuomboka suggest? What cultural traditions of other Zambian tribes are related to water resources, such as flooding or drought? How can the Zambezi River Authority incorporate multiple cultural traditions into management of the Zambezi water basin?

Human Rights perspective: If there is an adequate supply of water from the river, why do so many people suffer from preventable diseases? How can the water supply be improved to make it a safe source of drinking water? What is the connection between poverty and lack of access to safe water? How do chronic hunger and malnutrition affect a community's ability to meet basic needs? How do chronic hunger and malnutrition affect a community's ability to provide a good quality of life for its members? How can human rights - such as the right to education - help in improving access to water?

Gender perspective: How is water collected and transported for domestic use? Do men and women have comparable responsibilities related to water collection and transport? How do the different groups who live or work in this catchment area use the available water?

Scientific approach: How could you design a water quality study to provide the government with the necessary data to enact good policies to eradicate poverty and hunger? What would your monitoring goals be? What water criteria would you monitor? What steps could be taken to reduce the nutrient load and mining contaminants that affect surface water? What may be the causal link between lack of good drinking water and poverty? What new practices can be tested and piloted in the community that may make better use of the available water supply? To what extent should the great diversity of plant species be protected? Should harvesting of forest resources be allowed?

Sustainability perspective: What courses of action might the Zambezi River Authority promote? How could local governments work with the River Authority to ensure widespread improvement of water quality and other aspects of water management? How can the volume of effluent from mining operations be reduced without affecting mining production? Could the effluent water be diverted for some post-mining use, prior to being returned to the stream system? How can forest ecosystems be protected from overuse while at the same time allowing for resource harvesting? How sustainable is development in this case? How do environmental, social and economic factors interact with regards to water? Should the rates of mining or timbering be regulated or should people be allowed to develop resources to maximal levels to alleviate poverty? How can surface water be used for economic development with minimal loss to the system? How can forest products be harvested sustainably? What are some obstacles in providing improved water and sanitation services?

References

Hamre, C. (2007). 07. Kuomboka time. http://chadinzambia.blogspot.com/2007/04/07-kuomboka-time.html

Mann, Megan. Stories from Zambia: Water and Culture. http://www.peacecorps.gov/wws/educators/enrichment/africa/countries/zambia/zambiastories.html

Tembo, Mwizenge S. Nshima and Ndiwo. http://people.bridgewater.edu/~mtembo/menu/nshima/nshima.shtml

UNESCO World Heritage Convention. (2009). The Barotse Cultural Landscape. http://whc.unesco.org/en/tentativelists/5428/

UNESCO World Heritage Convention. (2009). Zambezi Source. http://whc.unesco.org/en/tentativelists/5427/

United Nations/World Water Assessment Programme (UNWWAP). (2009). Case Study Volume: Facing the Challenges, from United Nations World Water Development Report 3: Water in a Changing World. http://www.unesco.org/water/wwap/wwdr/wwdr3/case_studies/pdf/Case_Studies_Africa.pdf#page=15

2. Tunisia Case Study

Introduction

Tunisia, located in North Africa, is bordered by Algeria to the west, Libya to the south-east, the Sahara Desert to the south, and the Mediterranean Sea to the north and east (see Figure 1). The country covers 163,610 km^2 and its 2010 population numbered 10.48 million. Tunisia's landscape is diverse, with the Atlas Mountains in the north and the Sahara Desert and Matmata Mountains in the south. In 2006, 66% of the population lived in urban areas. Urbanization is expected to continue, largely through migration to coastal areas. Based on current trends, by 2025 some 75% of the population will live in urban areas.

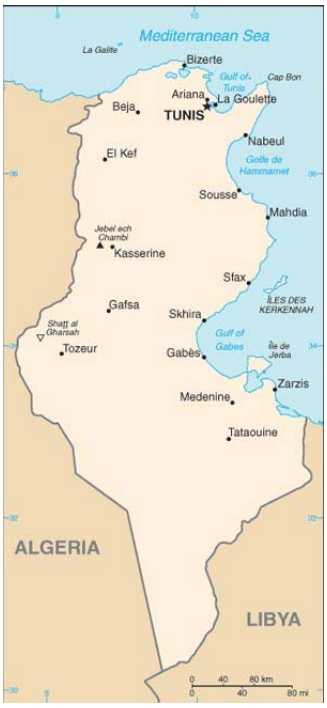

Fig. 1 Map of Tunisia

Tunisia, whose history dates back thousands of years, regained its independence in 1956. At that time, national priorities and ministries were established to direct progress in natural resource management, scientific and medical research, universal primary and secondary education as well as a strong system of tertiary education, and financial institutions. Today, national research priorities are focused on water management, as directed by the Arid Regions Institute, or ARI (Institut des Regions Arides). Goals of the Tunisian Ministry of Agriculture and Water Resources are to improve water resources availability, reduce pollution loads in the Mediterranean Sea and the Gulf of Tunis, and increase the sustainability of agricultural practices and livelihoods in the context of climate change.

Tunisia mandates nine years of free education for all children and offers financial assistance for uniforms, lunches, and other costs for needy children. Special education services are also provided for children. At the university level, over half of the students are women. However, geographic disparities in access to education still exist, specifically for rural populations.

Tunisia is a leader in the Arab world in promoting the legal and social status of women. A Personal Status Code was adopted shortly after independence that, among other things, granted women full legal status and outlawed polygamy. Rights of women and children were further enhanced by subsequent reforms in 1993. The government has supported a successful family planning program that has reduced the population growth rate to just over 1% per annum.

Major Climatic Regions of Tunisia

The predominant climate types are Mediterranean in the north and Saharan in the south. Four climatic sub-regions are: sub-humid in the far north, semi-arid in the north-west and at Cap Bon, arid in the centre and hyper-arid and desert in most of the south. Over 40% of the country lies in the hyper-arid zone. Although average annual rainfall amounts to 220 mm, geographic variation is substantial, with regional averages ranging from 1,500 mm in the north to 50 mm in the far south, in the heart of the Sahara.

An important wetlands area and World Heritage site is in the sub-humid northern region of the country. Garaet el Ichkeul National Park (see Figure 2) lies approximately 30 km south-west of the Mediterranean Sea. Lake Ichkeul is the only remaining great freshwater lake of a chain that once stretched across North Africa. The Ichkeul wetlands are the one of the most important sites for mating and migratory birds in the entire Mediterranean region. In the past, up to 300,000-400,000 birds were present at one time.

Figure 2 Ichkeul National Park

Lake Ichkeul is a brackish permanent lake indirectly connected to the Mediterranean Sea by the river Oued Tindja, which leads into a marine lagoon, Lac de Bizerte. The water levels and salinity of the lake and the surrounding marshes are affected by the flow of fresh water from upstream and exchanges with seawater downstream. The relative amounts of freshwater and sea water vary seasonally and annually, characteristic of Mediterranean climate. In the summer, the reduced level of incoming freshwater, in combination with high levels of evaporation, result in an overall drop in the level of the lake. There is also an increase in the concentration of salinity due to the influx of sea water. The waters in Ichkeul reach greatest salinity from July to October; there is a replenishment of fresh-water with the first autumnal rains. In 1996, the property was placed on the List of World Heritage in Danger. Ecosystem stability had been affected by an imbalance between freshwater and seawater, following the construction of dams. The property was removed from the Danger List in 2006, when restoration of the ecosystem was achieved.

The arid plains that mark the northern limit of the Sahara are characterized by low-lying areas, called chotts and sebkhats, which fill with water in winter and dry up in summer. The water is highly saline. The largest chott, Jerid, is a 500 km^2 salt lake. In the arid parts of the country, agriculture would be impossible without irrigation, oases, and water harvesting. A widely used traditional method of harvesting water in mountainous regions is the *jessour*, a system of collecting run-off from long slopes. Farmers build earthen dams (*tabias*) across the valley floors to trap the run-off water and silt.

Two major rural livelihood systems have traditionally coexisted in the arid regions. Sedentary farming in the mountains is traditionally centered on olive, fig and palm trees growing in *jessours*, and nearby cereal and legume crops in years of good rainfall. Agriculture in this arid region involves high risks on account of the very low amount and high variability of rainfall. The infrequent but heavy rainstorms can cause considerable damage to the *tabias* and much labor must be invested in repairing them. The

second type of livelihood is either nomadic (over long distances) or transhumance (over short distances) herding of camels, sheep, and goats in the plains between the mountains and the Mediterranean Sea.

However, over the last four decades, three major socio-economic changes have had a major influence on rural livelihoods. The first is that many men migrated to urban areas in northern Tunisia or Europe for work. This increased and diversified income sources for the rural families. The second change is the boom in the tourism industry, located along the coast of central and southern Tunisia. Tourism has increased the demand for both service sector jobs and fresh produce. The third change is the descent of sedentary farmers into the plains. The government invested heavily in water-harvesting systems in the plains, not only to reduce the risk of damage by floodwater to infrastructure in the coastal zones, but also to replenish the groundwater. At the same time, this created opportunities for agriculture based on harvested water. The descent into the plains had two other effects: it led to the abandonment of *jessours* in the most isolated mountain valleys, and it reduced the grazing resources. Communal grazing lands were increasingly transformed into private, cultivated land. At the same time, livestock numbers grew, further increasing the pressure on the dwindling grazing resources.

Management Approaches in the North-Western Sahara Aquifer System

In most of the arid and semi arid regions of the world, groundwater is the main source of water. However, long term development and management of groundwater in arid regions, depends on the establishment of a balance between withdrawal rate and recharge magnitude.

The North-Western Sahara Aquifer System (SASS), is a transboundary aquifer extending eastward through Algeria, Tunisia, and Libya. The SASS covers an area of over one million square kilometres and is the key water resource in the region. Although it has negligible recharge, it has experienced heavy exploitation (ground water mining) in the past thirty years. Ensuring the sustainability of this valuable, non-renewable resource is vital to the millions of people who depend on it for drinking water and irrigation. Recognizing the significance and fragility of this shared resource, the three countries, in collaboration with the Sahara and Sahel Observatory (OSS,) began a program of integrated water resource management. Two strategic components of the OSS focus on 1) joint management of shared water resources with a view to enhancing their governance by helping riparian countries upgrade knowledge and devise strategies and tools for effective cooperation; and 2) environmental monitoring aimed at strengthening OSS member countries' capacity to collect, process and disseminate information for sound decision-making.

Two of the major concerns of the SASS are inadequate recharge of the aquifer and surface salinization, mostly from the chotts, salt water depressions. The aquifer is most vulnerable to both threats where population density is highest, creating most demand on water resources. During the last twenty years, the number of wells and their abstraction rates have soared. Mathematical projections indicate that continuation of the present rate of withdrawal of groundwater would lead to additional drawdowns of 30 to 50 meters by the year 2050, which is non-sustainable.

Groundwater recharge techniques

Natural recharge to an aquifer in an arid region can occur in various ways, such as by direct infiltration in rocky areas in the mountains, infiltration from the beds of ephemeral rivers, subsurface drainage through alluvial material of valley beds, and rainfall into the alluvial material of the lower plains. Within a catchment area, recharge mechanisms vary due to differences in localized rainfall and geologic and physiographic features. The volume of groundwater recharge depends mostly on rainfall volume and duration, moisture content and profile characteristics of soil, and surface texture and vegetation.

The catchment of Zeuss-Koutine, with an area of 897 km^2, lies in south-eastern Tunisia, northwest of the city of Médenine. It extends from the Great Oriental Erg and Dahar plateau in the west, crosses the

Matmata Mountains between Béni Khdache and Toujane and the open Jeffara plain, then towards the Sebkhat of Oum Zessar before ending in the Gulf of Gabès.

The Zeuss-Koutine catchment has ephemeral wadis that can abstract runoff water from the streamflow. The abstractions, or transmission losses, reduce runoff volume as the flood wave travels downstream. Transmission losses from surface runoff are assumed to percolate into the underlying aquifers, which lead to the deep aquifer through faults. The transmission losses are an important component for replenishing the groundwater formations.

The Jeffara plain is home to over 1.4 million people. Anthropogenic pressure has increased considerably since the 1960s leading to environmental degradation in terms of reduced vegetation cover, and poor and eroded soils. The main stakeholders are: 1) government agencies, especially the Ministry of Agriculture; 2) professional organizations (farmers union, livestock breeders association, etc.); and 3) research institutions, specifically the Institute for Arid Regions (IRA) for specific scientific and technical support. These stakeholders share a history of developing collaborative and innovative water management strategies as they work together for sustainable economic growth and diversity.

Integrating Local Knowledge with Scientific Knowledge

In the second half of 1999, a small number of scientists, extension agents and farmers started to carry out joint experiments. Scientists had been trying for many years to find ways to reduce the maintenance requirements of traditional techniques such as *jessours*, as well as to test technologies to economize water usage. Whenever possible, they used local techniques as starting points. The challenge was to reduce the maintenance requirements of the *jessours* and to increase the productivity of farming based on rainwater harvesting.

Traditional water-harvesting techniques such as *jessours* must overcome numerous technical and socio-economic constraints to meet increasing water demands. One major technical constraint concerns the high ratio between the catchment and the cultivated area (100:5). Large catchments guarantee adequate run-off in years of low and average rainfall, but occasional instances of heavy rainfall cause floods which can damage all the *tabias* in a valley. Because the infiltration capacity of loess soils is limited, run-off water can stagnate for weeks in the *jessours*, causing damage to both trees and annual crops. A researcher at the IRA developed a technology to remove excess water. This was tested in a farmer's field in the village of Beni-Khdache. To avoid destruction of the spillways and of the dam during both normal and exceptional overflow, the lateral spillway was replaced by two joined tubes: one vertical and one sub-horizontal. The drainage system consisted of a basin and a floater. The initial results were not as positive as the scientist had hoped. As they continued testing, the farmer, who had observed the initial experiment, suggested improvements in the design.

One very successful technique to increase the efficiency of *jessours* is the "buried stone pocket" for underground irrigation of fruit trees. The original idea, introduced by a researcher, was to dig a planting pit lined with three or four layers of stones (limestone, sandstone, lime crust, etc.). Two or three sides of the pit are covered with plastic sheeting to prevent soil from entering the spaces between the stones. When the pit is filled again with soil, a T-shaped plastic tube is fixed vertically between the stones near the fourth side of the pit. Water flows by gravity through a rubber hose from a cistern higher up the slope to a tap near the pits. Another rubber hose connects the tap to the plastic tube in each "stone pocket" in order to irrigate the fruit-tree seedlings planted in it. This technology leads to faster growth of the individual fruit trees, while using very little water. Farmers who have tested it have observed substantial increases in fruit production.

The farmers did not simply adopt this technology; they adapted and improved it to fit their own circumstances. Reducing the depth and breadth of the planting pit, farmers laid out a small circle of stones, leaving an opening in the centre. They insert a plastic pipe vertically between the stones, cover the stones with soil, plant a tree seedling in the centre of the pit and give it water through the plastic pipe rather than by submersing the soil around the tree. One farmer decided to put the plastic pipe

closer to the tree so that he could continue to plough the land around it. Another farmer modified the "buried stone pocket" technique so that it could be used for growing watermelons. Scientists observed and learned from these farmers' experiments.

In response to the growing demand from urban areas and the tourist sector for a wide variety of fresh produce, farmers have begun to diversify the species of fruit trees planted in the *jessours*. Using grafting techniques, farmers are growing trees with combinations of apples and pears or peaches and plums. Farmers also graft onto the roots of *jujubier* trees (*Ziziphus lotus*) which allow young fruit trees to grow in the shade. Agricultural agents used to regard this as a "useless" species, systematically uprooting the trees in the plains of central Tunisia. The farmers, however, regard this plant as an indicator of reasonable levels of soil moisture and fertility. Some farmers now have more than ten species of fruit trees in their fields, a radical change from the traditional olives, figs and palms. It is not unusual to find several varieties of each species (early maturing to late maturing varieties), chosen by farmers with a view to spreading the risk of harvest failure.

One particularly promising experiment occurred in the foothills close to Gafsa (average rainfall 140 mm). It involved temporary storage of water in a small concrete dam on a large piece of marginal land that a farmer had bought ten years earlier. He built the dam in order to see how he could use water-harvesting techniques. Once the dam is full, the water is pumped to a large cistern constructed down slope close to his arable fields. Storing the water in a cistern avoids evaporation. This water is then used for supplementary irrigation of olives and almonds planted behind *tabias*. The local Regional Centre for Agricultural Development (CRDA), which monitored the results of this experiment, received requests from several other farmers interested in developing similar systems on their farms.

These practices are based in traditional, local knowledge and are consistent with the socio-cultural values and meaning systems of the people living in the communities. The farmers involved in the experiments are well known in their communities and by other farmers who want to try the innovations. The local CRDA has monitored the experiments carried out in the ISWC-Tunisia program.

The Challenge

While Tunisia has been proactively and collaboratively managing its limited water resources, continued demand due to increasing population, economic growth, and climatic conditions put increasing pressure on management effectiveness. Local, national, and transnational collaborations between scientists, government officials, and water users are essential to conserve and protect natural resources. How can Tunisia continue to protect against threats of salinization of groundwater and surface water resources while continuing to build human and resource capacities? What kinds of dynamic exchanges can be cultivated between traditional and scientific knowledge to derive sustainable growth and resource management?

Suggested Discussion Questions for a Multiple Perspective Analysis of the Case Study

Values perspective: How does universal education promote acceptance for the need to manage and conserve water? How does formation of transboundary commissions, such as the OSS, affect peoples' perceptions of upstream and downstream? How can urban and rural users of water sources be respectful of the diversity of users and demands on the water supply?

Historical perspective: Why do you suppose that ancient techniques of water management, such as *jessours*, have proven valuable in modern times? Why would rural livelihood systems, such as nomadism and transhumance, have developed? What can a natural site like Ichkeul Natural Park tell us about the past climate of Tunisia? How can we use that knowledge to make good decisions about the future?

Cultural Diversity perspective: Why do you think it is so important that farmers and researchers work together to conduct research on water management strategies? What can the two groups do collaboratively that neither one can do independently? Is it likely that using local knowledge as a beginning point for many water management innovations will encourage farmers to accept other innovations that may not be rooted in local knowledge? What kinds of pressures do nomadic and transhumance rural lifestyles place on water supplies?

Human Rights perspective: Is it equitable that water costs are the same in all parts of Tunisia, even in southern arid regions where much drinking water comes from desalinization efforts? How can universal education, including financial and educational support for the neediest students, contribute to participatory processes of governance? How can water management be more effectively implemented by recognizing and respecting local knowledge?

Gender perspective: How has the trend of migration by men to urban areas affected rural women? What kinds of water management issues might be differently viewed by women than by men? What kinds of leadership can women demonstrate in progressive Muslim societies?

Scientific approach: Can natural variations in rainfall volume and salinity levels of surface water be moderated to lessen threats to fragile ecosystems? How can surface water threats of salinization of the aquifer system be minimized? How does the use of dams in rainwater harvesting systems benefit or threaten groundwater recharge?

Sustainability perspective: Can eco-tourism, at Lake Ichkeul or sites in southern Tunisia, be used to support the integrity of unique and fragile ecosystems? The North Western Sahara Aquifer (SASS) is at risk of non-sustainable drawdown. Should industrial users have greater restrictions placed on their water use? How can continued demographic and economic demands for water be met, while protecting the quality and quantity of the non-renewable aquifer system?

References

Madikizela, M. The Science and technology system of the Republic of Tunisia. http://portal.unesco.org/education/en/files/55545/11998913265Tunisia.pdf/Tunisia.pdf

North-Western Sahara Aquifer System. http://nwsas.iwlearn.org/

Sahara and Sahel Observatory. Strategy 2010. http://translate.google.com/translate?hl=en&sl=fr&u=http://www.ossonline.org/index.php%3Flang%3Den&ei=GR6fTabCPIXKgQfkhrzgDw&sa=X&oi=traslate&ct=result&resnum=2&ved=0CCUQ7gEwAQ&prev=/search%3Fq%3Dsahara%2and%2Bsahel%2Bobservatory%26hl%3Den%26prmd%3Divns

Tunisia – Watershed of Zeuss-Koutine. http://www.unesco.org/science/doc/mab/Tunisia.pdf

UNESCO. World Heritage Convention: Ichkeul National Park. http://whc.unesco.org/en/list/8/

United Nations. (May 2004). National report on Millenium Goals. http://planipolis.iiep.unesco.org/upload/Tunisia/Tunisia%20MDG%20Report.pdf

United Nations/World Water Assessment Programme (UNWWAP). (2009) 3rd United Nations World Water Development Report: Water in a Changing World. http://www.unesco.org/water/wwap/wwdr/wwdr3/case_studies/pdf/Case_StudiesAfrica.pdf#page=12

U.S. Department of State. (Oct. 13, 2010). Background Note: Tunisia. http://www.state.gov/r/pa/ei/bgn/5439.htm

3. Thailand Case Study

Introduction

Thailand is a country of diverse geography, climate, and water resources. Located in Southeast Asia with a land area of over 500,000 km2, Thailand is comprised of a densely populated central plain, a seasonally barren north-eastern plateau, a mountain range in the west, and a southern isthmus which connects to Malaysia. The tropical monsoon climate results in seasonal droughts and flooding, which have led to national and regional development of canal and irrigation systems, especially in the central region.

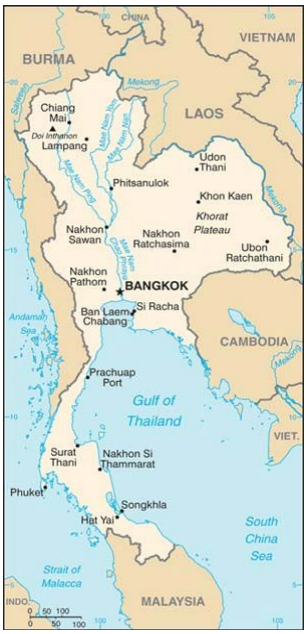

Figure 1 Map of Thailand

Thailand is the largest exporter in the world rice market. About 40% of its labor force and about 50% of the land is in agriculture. As Thailand continues to industrialize, its urban population, mostly in the Bangkok area, makes up about 32% of the total population. At present, water used for irrigation is equivalent to approximately 70 percent of the total water storage capacity of all reservoirs and structures. Thailand allocates about 10 percent of its national budget to irrigated agriculture, and its water policy calls for the nation-wide distribution of water for subsistence irrigation. In the mid-twentieth century, government policy promoted conversion of forests and swampland for agriculture, leading to widespread deforestation and watershed degradation. However, in recent decades, increasing urban migration and employment has reduced Thailand's rural farming population, while creating opportunities for reforestation.

The National, Economic and Social Development Plan (NESDP) is the main mechanism for policy development and planning for improved management of natural resources and environmental protection. The NEDSP supports regional and local participatory approaches to environmental concerns, as well as institutional reforms. However, despite policy reforms and widespread participation, the management of natural resources has not been uniformly integrated throughout the country. In the Chao Phraya River Basin extensive canal systems, complete with barrages which control and divert the water, provide irrigation water to over 1.0 million hectares. However, Northeast Thailand, located in the Mekong River Basin, depends mostly on seasonal rainfall for agricultural and domestic water needs. Typically, farmers rely on community reservoirs or on-farm ponds during the extended dry season.

Major Water Basins

Chao Phraya River Water Basin

The Chao Phraya River Basin is the most important Basin in Thailand. The Basin covers 30% of the land country, is home to 40% of the population, employs 78% of its work force, and generates 66% of its Gross Domestic Product (GDP). Overall, about 68% of the total population of the Basin is rural, but there is considerable variation with over 90% of the population being rural in the Upper Chao Phraya Basin compared to 45% in the Lower Chao Phraya Basin,

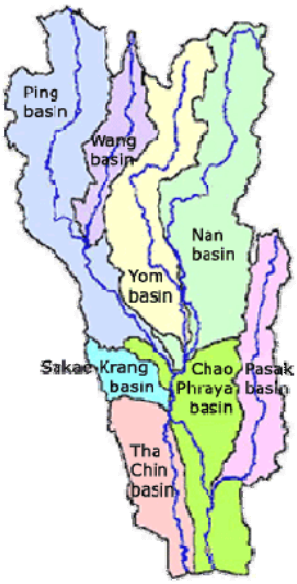

Figure 2 Chao Phraya Basin

Considerable inequalities exist in per capita income between urban and rural populations. Formal employment and social services, such as health and education, are also more available in urban areas. Over 90% of the Basin is either used for agriculture or covered with forest. In the later years of the 20th century, there was steady encroachment of people into forest areas for conversion to farm land, while cultivated land near urban centres had been converted to residential or industrial use. This trend of deforestation has been reversed, while the trend toward urbanization has continued. The on-going need to protect the upper catchment of the Chao Phraya Basin from degradation and soil erosion is a priority of the government.

Water availability is the key factor constraining future developments in agriculture in the Central Plain of the Chao Phraya Basin. Water management challenges for the future include water quantity and quality, flood control and warning systems, patterns of land use, and sustainability issues. One of the sustainability issues is the risk of salinization of freshwater. The maintenance of freshwater integrity is based on maintaining minimum stream discharges to repel salt-water intrusion at the lower reaches of rivers, minimizing levels of pollutants, and maintaining minimum dissolved oxygen levels. A minimum flow of 16m^3/s is currently considered sufficient in the lower reaches of the Chao Phraya river to repel saline intrusion. Planned irrigation systems and hydropower plants could potentially affect flow rates.

Mekong River Basin

The Mekong River is the twelfth longest river in the world. Its water Basin has an area over 800,000 km^2. The Mekong River Basin extends through six countries, including Cambodia, China, Lao People's Democratic Republic (PDR), Myanmar, Thailand, and Viet Nam. The Mekong River Commission (MRC), a combined effort of Cambodia, Lao PDR, Thailand and Viet Nam, hopes to protect the rich and diverse resources of the Mekong River Basin. The Cooperation for the Sustainable Development of the Mekong River Basin Agreement, signed in 1995, provided the framework for the MRC. The top priority of the 1995 agreement and its strategic plan was in ensuring the sustainability of water

resources and the environment while promoting overall Basin development. Fisheries, agriculture and navigation are some of the important issues that are central to the agreement. The specific programs established under the MRC strive for capacity enhancement and focus on the current and future needs of riparian countries. Further, the programs developed under the auspices of the MRC are expected to complement and support national and transnational development initiatives.

Water Sources, Uses, and Demands

The monsoon climate results in seasonal extremes of drought and flooding. An extensive system of dams, barrages, and canals assist in storage and flood control issues. In the dry season, water stored in reservoirs is distributed according to priorities. The allocation priority ranges from domestic use, agriculture, ecosystems, to prevention of sea water intrusion.

There are two major dams in the lower Chao Phraya Basin which are also important in the generation of hydro-electricity. As the population increases and industrialization spreads, the need for energy production has been rising as well. In order to reduce external dependency on energy, the government has been supporting regional and local hydropower development, considered good choices given the topographic and ecological variability within the country.

The main source of water for industry is aquifers. However, over-utilization of aquifers, especially in the Bangkok region, has caused serious land subsidence. Lack of investment in piped water systems has caused many municipalities and private users to install tubewells, tapping into groundwater supplies. The government has been promoting alternative water supplies and water-efficient processes. The availability of freshwater may be a constraint to future industrial expansion.

Water supplies for domestic purposes are provided by water service facilities in urban areas. For farm households, water is from piped systems, wells, and rivers. Over half of rural households consume water from unprotected sources, such as rainfall collection, rivers, canals and ponds. The majority of piped systems for farm households are operated and managed by village communities. Thailand increasingly encourages water user groups to actively participate in the management and allocation of water for regional and local communities.

Water quality has been deteriorating due to contamination from municipal wastewater releases, business activities, and agricultural wastes. As important as the irrigation system is in distributing water, is also distributes many kinds of pollution.

Transboundary and Regional Water management

Transboundary Efforts

Thailand's water Basins illustrate unique natural and human-influenced challenges for water management. The Chao Phraya Basin is the most developed in terms of integrated water resource management (IWRM). The system of dams, canals, and irrigation systems, under the auspices of the Metropolitan Waterworks Authority, stores and distributes water for agricultural, domestic and industrial users in the most heavily populated region of the country. On-going concerns in the Chao Phraya water Basin reflect increasing environmental demands from urbanization and industrialization.

In the Mekong River Basin, two primary concerns are 1) transnational water management and 2) adapting local knowledge and societal structures for more inclusive participatory water management. The Mekong River Basin drains the Northeast region, which includes the remote Korat triangle. In contrast, a transnational effort for water management at the level of the Basin has been established through the Mekong Water Commission (MWC). One demonstration site of the MWC is in the Lower Songkhram Basin.

The Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme (MWBP) is an initiative among the four Lower Mekong countries – Cambodia, Lao PDR, Thailand, and Vietnam. The program goal of the MWBP is conservation and sustainable use of wetland biodiversity, to be achieved

through capacity strengthening at regional, national and provincial levels. The MWBP uses two strategies in particular to address capacity-building: improving human and technical capacity to conserve and sustainably manage resources; and improving community-based natural resource management wetlands in the Lower Mekong Basin. Two projects of the MWBO are monitoring of river quality by school children and implementing Thai Baan research into the community.

Children attending schools near the lower 170 km of the Lower Songkhram River regularly monitored the river's water quality. By using simple and low cost materials and methods, the children have shown that water quality testing does not have to be conducted by non-local scientists using expensive equipment and sophisticated laboratories to generate useful data.

Thai Baan research, meaning Villager's Research, provides a platform for local people to be better informed and to more actively participate in decision-making processes. This process allows for a broader range of ideas and interests to be represented. The Thai Baan network has resulted in two informative products about the ecology, livelihoods, and biodiversity of the Lower Songkhram River Basin.

The Songkhram Demonstration Site has been working with educational administrators and teachers to find ways of integrating local knowledge gained from Thai Baan Research into the schools' curriculum, with particular focus on wetlands, local livelihoods and participatory research methodologies.

Local Community Efforts

These goals and strategies of the transboundary initiative have direct applicability in inland areas of the Mekong River Basin as well. Many parts of the Northeast region are characterized by subsistence rice agriculture, with most land holdings of 4 hectares. Rice is grown as a single, rain-fed crop during the monsoon months, with a wide variety of other cultivated crops. Local or regional irrigation systems are generally not available. Farmers use community reservoirs or on-farm ponds during the extended dry season. Aquaculture, or fish production in rice fields, is common as well. The depth and duration of flooding, in part, determine the type and extent of fish production. The Northeast region's relative poverty and aridity make aquaculture potentially more useful than in the Chao Phraya Basin, where it was introduced in the 1980s, but not widely adopted.

The extent of participation, by men or women, in organizations for resource management is affected by two factors: eligibility for membership and the balance of costs and benefits to be gained from involvement. Development projects promoting rice-fish culture or irrigation systems have not adequately addressed the needs and concerns of women farmers, in particular, who frequently are the decision-makers regarding household consumption. Most irrigation plans and designs are based on the assumption that the farm household consists of a male farmer, his wife and a number of children. The male farmer is thought of as being the sole manager and decision-maker regarding the farm. His wife is generally only referred to in terms of the units of labour she is expected to contribute to the irrigated agriculture enterprise. Lack of female involvement may also have limited the acceptance of physical changes in the rice field that usually need female approval in the matrilineal and matrilocal Thai society.

Lack of visible participation of women in resource management organizations cannot be construed as implying their lack of interest, nor does it imply that women do not influence what happens within the organization. Location of meetings, childcare concerns, and breaking with local customs may deter women from formal participation. However, many women succeed in getting their water needs accommodated through informal or formal means. Access to decision-making through informal means is not as secure, and control over water that is not sanctioned by democratically devised rules and principles are more prone to be influenced by unequal power relations.

The Challenge

While Thailand possesses abundant water resources, growing demand coupled with pollution puts an increasing pressure on these resources. Effective systems for conserving and protecting natural

resources have become central to national development projects. In order to best implement an integrated water resource management plan, Thailand should focus on human and resource capacity-building.

1. representative participation in formal water governing organizations,
2. local monitoring of water quality,
3. a nationwide system of irrigation and potable water piped systems,
4. measures to protect against industrial and agricultural run-off, and
5. patterns of agricultural land use to improve quality of life among rural communities.

Suggested Discussion Questions for a Multiple Perspective Analysis of the Case Study

Values perspective: Do men and women seem to equally value membership in formal water user group organizations? How does formation of transboundary commissions affect peoples' perceptions of upstream and downstream? How can upstream and downstream users of the river systems be respectful of the diversity of users and demands on the water supply? How can Thailand, through transnational, national, regional, and local initiatives, strengthen participation in decision-making about water management?

Historical perspective: How has the formation of the Mekong Water Commission (MWC) enhanced international relations? Has it created duplication of efforts that each of the four nations of the Lower Mekong Basin should work on independently?

Cultural Diversity perspective: How can the transnational Mekong Water Commission (MWC) share the demonstration sites' successes in water resource management and capacity-building with member nations? How can those successes be shared and modelled throughout Thailand? Why do you think it is so important that local children and adults, not just outside experts, are able to monitor water quality, conduct research on water management, and make decisions?

Human Rights perspective: How does Thai Baan research, as part of the Lower Songkhram demonstration site project, acknowledge local knowledge and participatory processes? How can local knowledge be used to help conserve biodiversity of the sub-basin? How can the extensive water infrastructure of urban areas be matched in rural areas?

Gender perspective: How could matrilineal and matrilocal aspects of Thai culture affect the acceptance of aquaculture in Northeast region farms? What kinds of water management issues might be differently viewed by women than by men? How can participation in formal water management organizations give women new opportunities for decision-making?

Scientific approach: Should non-source pollutants, such as wastewater and industrial pollutants, be monitored and regulated? How can local communities water data, such as in the Lower Songkhram Basin, be used to predict water distribution and quality patterns? How can use of aquaculture and local knowledge help to maintain biodiversity and water quality?

Sustainability perspective: How has the canal system in the Chao Phraya Basin contributed to economic growth and urbanization? Is the ability of hydropower, from damming the Chao Phraya River, to alleviate dependence on foreign sources of energy, worth the potential risks of reduced stream flow and possible salinisation of water at the delta? Should industries be given continued access to aquifers through piped systems and tubewells, or should limits or surcharges be placed on water use?

References

Little, D.C., Surintaraseree, P., Innes-Taylor, N. (1996). Fish culture in rainfed rice fields of northeast Thailand. Aquaculture, 140: 295-321.

Meinzen-Dick, R., Zwarteveen, M. (1998). Gendered participation in water management: Issues and illustrations from water users' associations in South Asia. Agriculture and Human Values 15 (4):337-345.

Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme. (MWBP). http://www.mekongwetlands.org/index.htm

Solow, J., Jonjuabsong, L., Hwai-Kham, A. (1991). NGO-Government Interaction in Rice-Fish Farming and Other Aspects of Sustainable Agricultural Development in Thailand. London Overseas Development Administration, Agricultural Administration (Research and Extension) Network.

United Nations/World Water Assessment Programme (UNWWAP). (2003) 1st UN World Water Development report: Water for people, water for life. http://www.unesco.org/water/wwap/case_studies/chao_phraya/index.shtml

United Nations/World Water Assessment Programme (UNWWAP). (2006) 2nd United Nations World Water Development Report: Water, A Shared Responsibility. http://www.unesco.org/water/wwap/wwdr/wwdr2/case_studies/pdf/thailand.pdf

U.S. Department of State. (Jan. 28, 2011). Background Note: Thailand. http://www.state.gov/r/pa/ei/bgn/2814.htm

Xiaogang, Yu (1998) Gender, Culture and Sustainable Watershed Management, Indigenous Asia: Knowledge, Technology and Gender Relations, AIT-GASAT Conference, Thailand, December 1-4, 1998.

Zwarteveen, M.(1997) Water: From basic need to commodity: A Discussion on Gender and water rights in the context of irrigation. World Development, 25(8): 1335-1349.

4. Lake Titicaca Basin Case Study

Lake Titicaca Basin

The Lake Titicaca Basin is composed of four major basins: Lake Titicaca, Desaguadero River, Lake Poopó and Coipasa Salt Lake. Desaguadero River is Titicaca's only outlet and flows into Lake Poopó, whose overflow gives rise to Coipasa Salt Lake. These four basins form the TDPS System, the heart of which is Lake Titicaca, the largest lake in South America. Situated between Peru to the west and Bolivia to the east, it is the highest navigable lake in the world. The TDPS System covers an area of approximately 140,000 km2 and is located between 3,600 and 4,500 meters above sea level. One of over 25 rivers, the Ramis River drains 26% of the tributary basin. Its flow is about 76 m^3/s. Overflow from Lake Titicaca drains through the Desaguadero River, observed to flow at 35 m^3/s. This flow represents only 19% of the lake's inflow. The difference is lost through evaporation, accelerated by the extreme solar radiation at high altitudes.

Figure 1 Woman and Reed boat at Lake Titicaca

The climate within the TDPS system is that of a high mountain tropical region. Precipitation varies between 200 and 1,400 mm. There are great seasonal variations, as the area usually has wet summers (December through March) and dry winters (from May through August). Titicaca's level fluctuates seasonally. During the rainy summer, the level of the lake rises, normally to recede during the dry winter. The average level is 3.810msnm +- 2.5m. Air temperature varies depending on latitude, longitude, altitude and proximity to the lake, with minimums of -10 to -7°C and maximums of 19 to 23°C. Humidity is low.

During dry seasons, glaciers have been the main source of drinking and irrigation water for many people living in the TPDS. By acting as reservoirs, glaciers regulate stream flow and diminish seasonal variations in water supply. However, climate variability and associated changes in ambient temperatures have affected the glaciers of the region. Between 1991 and 2003, measurements showed that Zongo and Chacaltaya glaciers decreased in area and volume. Chacaltaya glacier lost 97 percent of its mass between 1960 and 2003. To counterbalance the negative effects of glacial melting, more dams and reservoirs will have to be constructed.

Salinity is affected by climatic variability in the TPDS. Rainfall, greater in the northern part of the system, reduces the concentration of dissolved salt. Evaporation, greater in the southern part, increases the concentration of dissolved salt. In general, Lake Titicaca and its tributaries have normal values of water salinity (less than 1,000 milligrams [mg] per litre). Desaguadero River has values between 1 and 2 mg/litre, but downstream values are greater than 2 mg/litre. Lake Poopó has salinity values above 2,000 mg/litre due to natural conditions of high evaporation and low rainfall. Local mining activity also contributes to salt levels. Maximum salinity values were found in Coipasa Salt Lake and in the surrounding land.

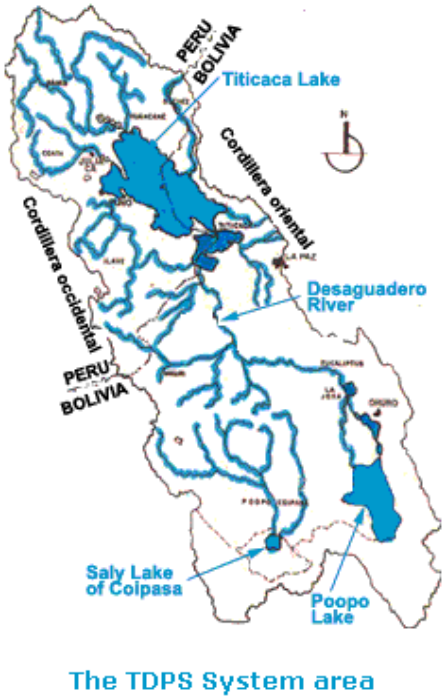

Figure 2 (http://www.unesco.org/water/wwap/case_studies/titicaca_lake/detailed_view.shtml)

Most extreme events in the TDPS system are related to flood risk conditions around Lake Titicaca, drought in the central and southern parts of the system and the incidence of hail and frost throughout the region. The 6.37m variation between maximum and minimum registered lake levels produced historical flood events in the lake and surrounding areas. The Master Plan of the TDPS system has required regulation works to be built that maintain the lake level at the minimum of 3,808 m.a.s.l. with a maximum of 3,811 m.a.s.l. during a normal hydrological cycle.

Governance and Culture

The area of Lake Titicaca is evenly distributed between Bolivia and Peru, countries that exercise an 'exclusive and indivisible joint ownership' over its waters. The joint ownership model applies to the entire catchment of Lake Titicaca, as a way of ensuring integrated management of the water system. Three institutions operate in the TDPS system area with clearly defined roles: the Ministry of Sustainable Development and Planning, in Bolivia, the Peruvian Development Institute, and the Binational Autonomous Authority of Lake Titicaca (ALT). ALT was created in 1996 through international law. Its main function is to decide, implement and enforce regulations governing water management and protection of the TPDS system within the framework of its Master Plan. ALT collaborates with the Peruvian and Bolivian Ministries of Foreign Affairs. Two national projects were established by ALT for Bolivia and Peru. The Bolivian project is the Unidad Operativa Boliviana (Bolivian Operative Unit, UOB), located in La Paz, and the Peruvian project is called the Proyecto Especial del Lago Titicaca (Lake Titicaca Special Project, PELT), located in Puno. ALT is responsible for coordinating actions with national governments and for centralizing information.

ALT administration is based on Integrated Water Resources Management (IWRM). The general model promotes coordinated management and development of water, land and related resources, although certain border conditions do not yet permit a complete implementation of the model. Nevertheless, two aspects are coming along slowly: valuing water as an economic good and an improved level of community participation in water management issues.

Since the creation of the Binational Autonomous Authority of Lake Titicaca (ALT) in 1993, several efforts have been made to consolidate the available information on water resources in the TDPS system. Most of the information was scattered among different institutions in Bolivia and Peru. Early

in the 1990s, international consulting firms prepared a Master Plan that compiled most of the available information about the TDPS system. The creation of ALT and the elaboration of the Master Plan allowed data and information from different sources to be systematized and it is now possible for Bolivia and Peru to share this information through ALT. However, it is still necessary to improve data collection and dissemination and to standardize the information generated by different institutions.

The pre-Hispanic ethnic groups on both sides of the lake maintain ancestral cultural patterns which are unlike those of Western culture. The high-plateau populations practice their own cultural traditions, which prevail in spite of four centuries of Spanish colonization. Bolivia's population is estimated to be 55% Indigenous, the largest ethnic groups being Quechua (29%) and Aymara (24%) (http://www.state.gov/r/pa/ei/bgn/35751.htm) Most Peruvians are either Spanish-speaking mestizos or Amerindians, largely Quechua-speaking. Quechua, Aymara, and other Indigenous languages have official status. (http://www.state.gov/r/pa/ei/bgn/35762.htm) Languages, traditions, beliefs and customs are intermingled in different forms of social organization, cycles of social life, feasts and rituals, music and dances and in the preservation of sacred places. Among the Aymaras, Lake Titicaca is known by the name of Lago Sagrado (Sacred Lake). According to Inca cosmology, Lake Titicaca is the site of the origin of human life.

The high-plateau populations practice an agro-centric cultural pattern: agriculture is the central reference point of all human activities. Agriculture and cattle-raising activities are the main economic activities, and limited forestry and fishing operations. The value of work is the unifying social force and the only source of wealth. Related cultural patterns include 1) the desire to minimize risk rather than maximize production, 2) a system in which communal property is superimposed over individual holdings, and 3) rules for how upstream communities share water resources. While Indigenous cultural practices and laws co-exist with Western practices, they often result in underdevelopment and social exclusion.

Poverty is the most critical social problem in the TDPS system, affecting both rural and urban populations. Poor nutrition and lack of clean water and sanitation are major factors affecting the health and well-being of the communities. In the TDPS system, roughly 20% of people have access to improved water and sanitation systems. The rate of infant mortality is high. Further, between 70 - 80% of children are chronically malnourished. The illiteracy rate is 22 percent: it is higher in rural areas than in cities, and within rural areas, it is higher for females. Extreme poverty and a lack of opportunity induce the rural population, especially young people, to migrate to the cities, where they crowd into degraded districts. In 1993 it was estimated that GNP per capita in the Bolivian sector of the TDPS amounted to 35 percent of the national value. (http://www.unesco.org/water/wwap/wwdr/wwdr1/)

By the middle of the twentieth century, Bolivia and Peru had independently begun reform on land ownership. Land was formerly concentrated among a few owners of large land holdings. In Bolivia the Political Constitution declared rural property in the TDPS area inalienable, meaning that it cannot be sold or used as collateral for a loan. In the current model, rural property is fragmented into numerous small plots that are then divided through inheritance into still smaller plots. Only small-scale subsistence agriculture is possible under this model of land ownership.

Uncertainty of Water Resources

Climate variability, including extremes of temperature and surface water, creates challenges for farmers. Their primary survival strategy is to diversify their crops in the hope of minimizing risks. Floods and droughts can cause loss of genetic diversity in local species, if farmers must buy imported seeds for future crops. Hail and frost cause significant agricultural losses, especially in areas away from Lake Titicaca, which provides thermal insulation. Water salinity, a problem particularly in the south, severely limits the soil's agricultural capacity.

Water Needs, Uses, and Demands

The economic value of water is not fully recognized, particularly in rural areas. There is no water use rate and use of water for irrigation is defined by customary practice. The two main uses of water in the system, human consumption and irrigation, are not in conflict at the present time. There is, however, a potential conflict between upstream and downstream users, notably with respect to water for irrigation. The model provided by customary use and the way in which communities have traditionally related to each other play an important role in determining distribution patterns and claims. Upstream communities consider that they have priority over downstream communities through a complex system of retributions and favours.

Health issues related to improved drinking water and sanitation are yet to be fully resolved. Improved water supplies in the cities and towns of the TPDS are typically managed by the municipalities or by the community itself. However, the city of El Alto, Bolivia had a drinking water system and a wastewater treatment system administered by a private company, Aguas del Illimani. However, in January 2005, the inhabitants of El Alto protested the thirty-year concession for the water and sewage services with Aguas del Illimani (Waters of Illimani). After a week of civil disturbances and the resignation of the Constitutional President of Bolivia, the government made a unilateral decision to end the water concession with Aguas del Illimani.

The other main cities in the TDPS (Oruro, Puno and Juliaca) do not have appropriate systems and their sewage disposals are a cause of water contamination. The most polluted areas affected by sewage discharge are Puno's interior bay, the lower course of the Coata River, and Lake Uru Uru. In the Puno Bay region, high values of fecal-coliform (1,000 ppm) have been found. Additionally, both water and fish from Lake Titicaca reveal high parasite levels, probably due to inappropriate disposal of wastewater in the cities of Puno and Juliaca in Peru, and Copacabana in Bolivia. Parasites infect humans as well.

Water demand for mining and industrial activities is not a major problem inside the TDPS system because there are few industries and their water consumption is very low. Water use for mining has not been measured, but is considered insignificant. Conversely, mining is an important source of water contamination. High concentrations of arsenic are found in the western branch of the Desaguadero River. Lake Poopó and Coipasa Salt Lake have high levels of lead, cadmium, nickel, cobalt, manganese and chromium. In Puno Bay, mercury and arsenic concentrations of 0.4 ppm have been found in mackerel.

Energy production is not a major activity in the TDPS system. Energy consumption in the area is low and the principal source of energy is biomass (about 70%). Only 21 percent of homes on the Peruvian side and 29.8 percent in Bolivia, mainly in urban areas, have electricity. This electricity is generated outside the TDPS system.

The Challenge

Lake Titicaca Basin is a region with adequate water and other resources to facilitate economic development and enhanced quality of life. Extreme poverty, illiteracy, and chronic health problems could be ameliorated with sustainable development and management of existing resources. The ecosystems of the region have been changing in response to stressors, including loss of glaciers, heavy metal contamination, and increasing levels of salinity. The human resources channeled through binational and community governance structures, in addition to Indigenous and Western knowledge systems, could create successful plans for sustainable development.

Specifically what resources are available to address the social and environmental challenges, of the Lake Titicaca Basin? How can a greater percentage of the population, especially in rural communities, get access to safe water and improved sanitation? How can poverty, malnutrition, and illiteracy be alleviated, while assuring sustainable socio-economic development and preserving a healthy ecosystem? How can agriculture be advanced beyond a subsistence level?

Suggested Discussion Questions for a Multiple Perspective Analysis of the Case Study

Values perspective: What value/s of the Indigenous populations seems to be a priority in decision-making regarding quality of life? Are these same values evident values in Western ways of thinking? If tourism to the lake is encouraged, would the potential benefits from economic development be in harmony with the religious and cultural significance of the lake? Can Indigenous values and beliefs be maintained despite increased interactions with those who hold different beliefs?

Historical perspective: How has the formation of the Binational Authority of Lake Titicaca (ALT) enhanced international relations? Has it created duplication of efforts that each state (Peru and Bolivia) continue to work on independently? What kind of model has the ALT provided for governance at national and local levels? Should the ALT expand their authority to direct installation of improved water and sanitation services?

Cultural Diversity perspective: How can the cultural values of the Indigenous people, including Aymaras and Quechuans, be respected while reformulating the land holding customs? How can traditional agricultural practices be supported by technologically advanced practices that could increase yield in diverse environmental conditions including frost and drought? Can people who have relocated to urban areas maintain traditional values in a non-agrarian society? Can the Indigenous people maintain traditional languages and other customs if they incorporate Western views of society and economic partnerships into their own? What benefits might occur to Western thinkers if they adopted Indigenous world views into their own? Lake Titicaca is considered a sacred lake by many Indigenous peoples of the TDPS region. If tourism to the lake is encouraged, could the potential benefits from economic development be in harmony with the cultural and historical significance of the lake?

Human Rights perspective: Could poverty be alleviated if more people in rural areas had access to improved water and sanitation services? How can enhanced literacy contribute to better quality of life for all? Why do you suppose young people tend to emigrate to urban areas, rather than staying in traditional rural communities?

Gender perspective: Why do you suppose rates of illiteracy and poverty are higher in women than in men? What lifestyle patterns or customs do you think may be contributing factors? How can a greater percentage of the population, especially in rural communities, get access to safe water and improved sanitation? What factors might contribute to the high infant mortality rate? How can poverty, malnutrition, and illiteracy be alleviated, especially among infants and women?

Scientific approach: Seasonal glacial melting has long been part of the water cycle of the TPDS. How might the 97% volumetric loss of Chacaltaya glacier affect the water supply for the TPDS basin? What other sources of water can make up the difference? How might loss of glacial melt affect the salinity of the southern TPDS basin? What effects might construction of dams and reservoirs have on downstream portions of the catchment area? How could loss of the glaciers affect the regional water cycle? How can heavy metal contamination from mining operations be minimized? What standards exist for heavy metal contamination? Is it possible that heavy metal contamination in the Desaguader River can affect other parts of the TPD? Should more stringent standards be implemented to maintain water quality in the lake? Begin hydro-production, desalinate?

Sustainability perspective: What are the obstacles in providing improved water and sanitation services? What natural resources could be used to improve the economic development of the basin? Should the rate of resource use be regulated by the ALT or should people be allowed to develop resources to maximal levels to alleviate poverty? What are possible effects of heavy metal contamination in mackerel and other game fish? What are the tolerance levels of aquatic, plant, and game fish to heavy metals? Should more stringent standards be implemented to maintain water quality in the lake?

References

Internal Work Group for Indigenous Affairs. Indigenous peoples in the Peru. http://www.iwgia.org/sw32571.asp

Quinn, L. (2007). Lake Titicaca Photos. http://htmlhelp.com/~liam/Peru/Puno/LakeTiticaca/

UNESCO World Heritage Convention. (2005). Lake Titicaca. http://whc.unesco.org/en/tentativelists/5080/

United Nations/World Water Assessment Programme (UNWWAP). (2003) 1st UN World Water Development Report: Water for people, water for life. http://www.unesco.org/water/wwap/wwdr/wwdr1/

United Nations/World Water Assessment Programme (UNWWAP). (2006) 2nd United Nations World Water Development Report: Water, a shared responsibility. http://www.unesco.org/water/wwap/wwdr/wwdr2/

United Nations/World Water Assessment Programme. Detailed view of Lake Titicaca Basin. http://www.unesco.org/water/wwap/case_studies/titicaca_lake/detailed_view.shtml

U.S. Department of State. (2010a). Background Note: Bolivia. http://www.state.gov/r/pa/ei/bgn/35751.htm

U.S. Department of State. (2010b). Background Note: Peru. http://www.state.gov/r/pa/ei/bgn/35762.htm

Resources

A selection of resources are listed here as a starting point for teachers to use in their classrooms with the Multiple-Perspective Tool. Searching on internet will provide you with many more interesting resources that may be more relevant to your local or national contexts.

General Websites

- National Geographic, "Freshwater" - http://environment.nationalgeographic.com/freshwater/
- Water for the Ages - http://waterfortheages.org/
- Waterlife - http://waterlife.nfb.ca/
- WaterWorld - http://community.waterworld.com/
- Running Dry - http://www.runningdry.org
- Imagine H2O - http://www.imagineh2o.org/
- International Decade for Action "Water for Life" 2005-2015 - http://www.un.org/waterforlifedecade/
- The Water Project - http://thewaterproject.org/
- World Water Day - http://www.worldwaterday.org/
- World Water Council - http://www.worldwatercouncil.org/
- World Water Assessment Programme - http://www.unesco.org/water/wwap/

Websites for Kids

- Learn about Water Discover Water Project – http://www.discoverwater.org/
- USGS: Water Science for Schools - http://ga.water.usgs.gov/edu/
- Kidzone: The Water Cycle - http://www.kidzone.ws/water/
- Science Kids - http://www.sciencekids.co.nz/sciencefacts/water.html
- Know H2O - http://knowh2o.org/
- EPA: Water Kids - http://water.epa.gov/learn/kids/waterkids/kids.cfm
- Water Education Foundation: Water Kids - http://www.watereducation.org/doc.asp?id=1022
- Natural Resources Defense Council: For Kids - http://www.nrdc.org/reference/kids.asp
- Kids R Green - http://www.kidsrgreen.org/
- Eartheasy, Environmental Websites for Kids - http://eartheasy.com/blog/2009/03/environmental-websites-for-kids/

Websites: Teaching Resources

- Know H2O - http://knowh2o.org/teach/
- Project Wet - http://www.projectwet.org/
- The Water Project - http://thewaterproject.org/resources/
- Water Aid Learn Zone – http://www.wateraid.org/international/learn_zone/
- Water for All: Oxfam Education – http://www.oxfam.org.uk/education/resources/water_for_all/water/gettingstarted.htm
- Water Rights and Wrongs by Young people of the World - http://hdr.undp.org/en/media/water_rights_and_wrongs_english.pdf
- Project Learning Tree - http://www.plt.org/
- Kids for Saving Earth - http://www.kidsforsavingearth.org/
- Facing the Future - http://facingthefuture.org/
- H2Ooooh! Initiative - http://www.h2ooooh.org
- Australian Water Education Toolkit – http://www.environment.gov.au/water/education/
- International Year of Chemistry - http://water.chemistry2011.org/web/iyc/experiments

Websites: Tools and Resources

- National Geographic, Water Footprint Calculator - http://environment.nationalgeographic.com/environment/freshwater/water-footprint-calculator/
- National Geographic, Signs and Solutions - http://www.nationalgeographic.com/signsandsolutions/
- The World's Water - http://www.worldwater.org/
- Learn about the Water Crisis - http://www.onedrop.org/en/UnderstandTheWaterCrisis/water-crisis.aspx
- Aqua, a Journey into the World of Water - http://www.onedrop.org/en/projects/projects-overview/AquaNorthProject/SchoolZone/YouthsCorner.aspx
- Educating Young People About Water – http://www.uwex.edu/erc/eypaw/
- Water Resources Education - http://clean-water.uwex.edu/

Websites: Articles

- Tunza Magazine: Water – http://www.ourplanet.com/pdfs/Tunza_6.3_EN.pdf
- National Geographic, "Water: A Special Issue" - http://ngm.nationalgeographic.com/2010/04/table-of-contents
- Nature, "Global Water Crisis" - http://www.nature.com/nature/focus/water/
- New York Times, "Water Pollution" - http://topics.nytimes.com/topics/reference/timestopics/subjects/w/water_pollution/index.html
- Global Issues, "Water and Development" - http://www.globalissues.org/article/601/water-and-development
- NASA Earth Observatory, "The Water Cycle" - http://earthobservatory.nasa.gov/Features/Water/

Videos: Documentaries

- TheWaterChannel – http://www.thewaterchannel.tv/
- Flow: For Love of Water (2008) - http://topdocumentaryfilms.com/flow-for-love-of-water/ and http://www.flowthefilm.com/
- A World Without Water (2006) - http://topdocumentaryfilms.com/the-world-without-water/
- Between the Tides (2009) - http://lifemorenatural.com/?p=371
- Blue Gold: World Water Wars (2008) - http://topdocumentaryfilms.com/blue-gold-world-water-wars/
- Waterlife (2009) - http://waterlife.nfb.ca/
- Tapped (2009) - http://topdocumentaryfilms.com/tapped/ and http://www.tappedthemovie.com/
- One Water (2008) - http://www.onewater.org/movie
- Running Dry (2005) - http://www.runningdry.org/what.html

Videos: Short Clips and photos

- National Geographic, "Why Care About Water?" - http://video.nationalgeographic.com/video/player/environment/habitats-environment/freshwater/env-freshwater-whycare.html
- TED, Michael Pritchard's Water Filter Turns Filthy Water Drinkable - http://www.ted.com/talks/lang/en/michael_pritchard_invents_a_water_filter.html
- Life is Water - http://www.jennwarren.net/#/life-is-water and http://www.youtube.com/watch?v=CkxLWHrh2io
- Time, "World Water Crisis" - http://www.time.com/time/photogallery/0,29307,1724375,00.html

Organizations

- UN-Water – http://www.unwater.org/
- UNESCO Division of Water Sciences – http://www.unesco.org/new/en/natural-sciences/environment/water/
- UNESCO Institute for Water Education (UNESCO-IHE) - http://www.unesco-ihe.org/Education
- International Hydrological Programme (IHP) – http://www.unesco.org/new/en/natural-sciences/environment/water/ihp/
- Charity: Water - http://www.charitywater.org/
- International Secretariat for Water (ISW) - http://www.sie-isw.org/
- Alliance for Water Education - http://allianceforwatereducation.org/
- Water.org - http://water.org/
- Global Water - http://www.globalwater.org/
- Global Water Initiative - http://www.globalwaterinitiative.com/
- Water Environment Federation - http://www.wef.org/

UNESCO has launched the *“ESD Learning & Training Tools”* series to enhance the availability of teaching, training, learning and resource materials on Education for Sustainable Development (ESD) issues through a wide set of practical tools. In particular, this series provides individuals, communities and governments that are at different stages in their understanding of the benefits of a sustainability approach and the role of education in it, with practical tools to review their situations and put in place ESD actions.

UNESCO has prepared *Learning about Water - Multiple-Perspective Approaches* as a thematic companion to *Exploring Sustainable Development: A Multiple-Perspective Approach* to focus on applying multiple perspectives for ESD to freshwater issues. It contains lesson plans, questions, lists of teaching resources including online videos, and case studies. Students are guided to understanding through eight unique, but overlapping, perspectives (scientific, historical, geographic, human rights, gender equality, values, cultural diversity, sustainability) on the relationships within natural systems and between natural systems and human society.