MODULE 2

WHAT IS HAPPENING TO OUR FRESH WATER RESOURCES

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IGES
Institute for Global Environmental Strategies (IGES)
2003
MODULE 2

WHAT IS HAPPENING TO OUR FRESHWATER RESOURCES

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2003
Water is more critical than energy.
We have alternative sources of energy.
But with water there is no other choice.

- Eugene Odum
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About the material

Welcome to this package of educational materials.

The package is prepared for promoting community awareness and action on the conservation and management of wetlands and wetland resources.

The package has four modules targeted for different groups of people in a community. These are,

Module 1: Let us keep our wetland healthy
Module 2: What is happening to our freshwater resources?
Module 3: Developing objective-oriented program
Module 4: Participatory rural appraisal (PRA)

This package and its modules are based on the two assumptions.

1. Environmental problems are a common concern, the solution of which requires the active and responsible involvement of the entire community.

Explanation: A community consists of diverse groups of people. They have different viewpoints on the community problem. Some know the problem fully while others may not know it at all, or know it only partially. Similarly, some may be highly vulnerable to the problem, while others may be only partially vulnerable, or not at all. In order to tackle this common problem, the concerns and needs of these groups should be addressed fully.

So, identify stakeholders of the community (students, parents, teachers, local leaders, NGO representatives, etc.).

2. The collective action is possible only when all stakeholders of a community develop a clear common understanding about the issue.

Explanation: Different groups should be brought together; they should be made aware of. Once they realize the situation, they need to be taught in a way they develop the common understanding about the issue, particularly managing and tackling them jointly. For this, the following steps are proposed.
(1) **Learn** (L) about the issue thoroughly
(2) **Experience** and **evaluate** (E) the knowledge
(3) **Adapt** (A) the knowledge for your community
(4) **Promote** (P) the knowledge

This is what has been called the LEAP method, which represents the first letter of the sequence of the “Learn, Experience and Evaluate, Adapt and Promote” steps. A short description of each step is given below.

**Step 1: (L) Learn about the issue thoroughly**
Before putting them into action, participants should understand the issue and be fully aware of it, especially its nature, scope, context, responsible factors and its possible solution. But participants cannot do it without any guidance. Here lies the responsibility of a facilitator. Only an informed facilitator can pass the information effectively on to the participants.

Taking these things into consideration, materials on different topics have been put together in a simple way. The facilitator should read it carefully and understand the issue thoroughly. Then he/she should teach participants with the help of the teaching outline annexed.

**Step 2: (E) Experience and evaluate the knowledge**
Once the participants understand the matter thoroughly, they should be given the chance to apply their new knowledge in the real world of work. The direct and first hand experience facilitates them to integrate theory into practice. The hands-on experience enables them to evaluate the topic in terms of its practicality, replication and sustainability. In fact, this step is crucial to participants to make any decision on whether to take the issue seriously or drop it off completely. Participants gain the first-hand experience while applying the knowledge in the real life situation.

**Step 3: (A) Adapt the knowledge for your community**
The knowledge and skills will be in limbo if they are not used. They will be stagnant and become a dead wood. The knowledge
should be lively and living by using it time and again. Participants should think of a site, where they can adapt it so that the acquisition becomes a regular practice.

**Step 4: (P) Promote the knowledge**

The knowledge should not be confined to the facilitator and the participants only. They should, in turn, share their knowledge with others until the idea becomes integrated into the practice. The knowledge should be disseminated as much as possible. Participants have to build up the capacity of the community to retain, use and promote the knowledge.
Tips for the facilitator

Who can be the facilitator? A teacher, NGO representative, social worker or researcher having an interest in the conservation of wetlands can be a facilitator. The main function of the facilitator is to impart knowledge and skills to the participant. Prior to the use of this material, the facilitator should read and understand the intention of this package.

1. Read the material and understand the basic concept of the issue thoroughly.
2. Understand the expectations and experiences of each participant at the beginning of the session. This will enable you to plan your activities for the session.
3. Conduct the session at or near the site as far as possible so that you will be able to deal with the real world. Use local examples, resources and hands-on experiences. Let them use their all six senses.
4. Use the teaching outline included in the booklet. This has been provided to help the facilitator concentrate on how to present the materials to participants.
5. Try to use the problem-solving methods of teaching such as demonstration, field visit, issue-based discussion, etc. in a way participants get a maximum opportunity in hands-on activities.
6. Guide participants to develop a plan of action on the application as well as dissemination of the knowledge in the community.

Should you have any comments or suggestions on this booklet, please send them to the following address.

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What is happening to our freshwater resources?

Why this module: Wetlands are found in the area where a hydrological regime occurs. Its ecological character depends on spatial and temporal variation of water depth, flow patterns, water quality as well as the frequency and duration of inundation. Some wetlands like the coastal wetland and the marine wetland are often highly dependant on inputs of freshwater. The integrity of wetland ecosystems is prone to human modifications (such as abstraction, storage and diversion of water for public supply, agriculture, industry and hydropower). In this way water is an integral part of the wetland ecosystem.

Issue
Conserving freshwater resources

Target
High school teachers

Objective
Provide the basic knowledge on the availability and sustainable management of freshwater resources

Demonstrated ability
At the end of the instruction, the participant should be able to discuss, describe and explain the major concepts of sustainable management of freshwater resources.
Step 1: Learn about the issue thoroughly

The topic is organized into four parts, (1) concept and availability of water, (2) renewability, (3) why worry about water resources and (4) global efforts.

Part 1: Concept and availability of water

What do we know about water?
- Physically water is a liquid.
- Chemically water is made up of two parts of hydrogen (H) and one part of oxygen (O). Its chemical formula is $H_2 + O = H_2O$.
- Water fills lakes, wells, streams and rivers.
- Water is indispensable for life.

Nature of water
- Water is a superior solvent able to dissolve a large variety of compounds.
- It has no shape, no color, no taste and odor.
- It is renewable.
- It is the only natural resource found in all forms; solid, liquid and gas.
- It expands when it freezes. Water, unlike other resources, decreases its volume when cooled down, but increases from $4^\circ$ to $0^\circ$ Celsius. That is why water pipes get burst when water freezes below $4^\circ$ Celsius.
Plenty of water (Photo: Bishnu Bhandari)
Importance and benefits
Water practically occurs everywhere. It is an essential element for life and called the bloodstream of biospheres.

Research works have shown that
- A human being has about 65% water in the body.
- A tree is 60% water by weight.
- A jellyfish has more than 90% water.
- About 2000 liters of water is needed to produce a kilogram of rice.

Water is crucial to socio-economic development. The development of water resources has significantly contributed to;
- Providing food security
- Producing electricity
- Achieving economic growth
- Meeting basic needs

However, the development of water resources is not substantial and the benefits are not equally distributed among, and shared by, all players.

Benefits are of two kinds; direct and indirect. Direct benefits are called uses arising out of direct interaction with water resources. Indirect benefits are known as functions.

Direct benefits of water resources are presented in Box 1. It should be noted that agriculture uses approximately 70% of the total freshwater.

**Box 1: Direct benefits**

- Drinking and personal use
- Domestic use
- Agricultural use
- Industrial use
- Hydro-power use
- Commercial use
- Sports and recreational use
Indirect benefits of water resources are summarized below.

1. **Health function**: Safe water is crucial for protecting the survival of a healthy population.

2. **Habitat function**: According to ecologists, water is essential in maintaining habitat for aquatic flora and fauna.

3. **Carrier function**: Water provides two carrier-functions such as carrying dissolved materials (hydro chemists) and the eroded materials (geographers).

4. **Production function**: Water provides two production-related functions, (1) plants and trees are feeding on water passing through the root zone, and (2) industries and urban societies are feeding on water passing through aquifers and rivers.

5. **Religious and psychological function**: Water is considered holy in major religions for cleaning, washing, offering, spiritually purifying, etc.
Theories

There are two general theories about water.

A. Water is cheap, abundant and perpetually available.

1. Water covers about 71% of the Earth surface. The area covered by water is called hydrosphere. This is the reason why the Earth planet looks like a “blue” planet from the outer space. The rest of 29% area is the land where we live.

2. If this water were to spread evenly over the Earth surface, it would form a thick layer of 3,000 meters.

B. Freshwater resource is precious, finite and irreplaceable.

1. Nearly 97% of the Earth’s water is found in the ocean. The ocean water is too salty for drinking and growing crops. It also cannot be used in industries except cooling. A liter of the ocean water contains 35% salt and approximately 3.6% solid matters.

   Note: The brackish water is the mixture of freshwater and ocean water found near or at the mouth of a river.

2. Only 3% water is freshwater i.e., usable for living beings. In terms of accessibility, only 0.003% of the Earth’s total water is available to humans. They are easily found in lakes, rivers, streams, soil moisture, exploitable underground water and atmospheric vapor.
3. The rest of 2.997 % of freshwater is locked up as ice in the poles and in glaciers or in ground water i.e., too deep and too expensive for men to extract. See Box 2 below for the summary of water available in the Earth.

<table>
<thead>
<tr>
<th>Box 2: Total water in the Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean Water = 97 %</td>
</tr>
<tr>
<td>Freshwater = 3 %</td>
</tr>
<tr>
<td>- Easily available = 0.003 %</td>
</tr>
<tr>
<td>- Not accessible = 2.997 %</td>
</tr>
</tbody>
</table>

A simplified example
Let us assume that the Earth’s water is in a tank of 100 liters.
1) Nearly 97 % liters is salty and unfit for use by humans, animals and plants.
2) Only 3 liters is available as freshwater which is good for use for humans, animals and plants but 99.9% (of 3 liters) is inaccessible i.e., too deep, too far and too expensive for our use because of their locations such as poles, glaciers and deep aquifers.

An analogy of the Earth water in a water tank

100 Liter

100 %

3 Liter

2.997 Liter

Inaccessible Freshwater 2.997 %

0.003 Liter (1/2 Teaspoon)

Easily Available Freshwater 0.003 %

Freshwater 3 %
3) Only 0.1% of 3 liters, or 0.003% of total water in the tank is accessible for our use, which is about half of a teaspoon. In a tank of 100 liters of the Earth water, only a half a spoon is accessible for our use.

**Sources of freshwater**

Freshwater is available from the following sources.

1) Rain (rain water is a pure water but gets polluted as it travels to the Earth)
2) Surface (lakes, rivers, streams, wetlands, reservoirs, etc.)
3) Aquifers (underground water)

Stream as a source of freshwater (Photo: Bhandari)

Pores, spaces, water saturated layers of sand, cavity, gravel or bedrock that can yield an economically significant amount of water is called aquifer. The aquifer is also called the underground lake. The aquifer is always moving slowly.
Our concern
Our main concern is freshwater because
- It is very little (only 0.003 %) of the Earth’s total water, or 0.1% of total freshwater. This is the water human beings, plants and animals use for their survival. Without water there cannot be any life.
- Its availability is not constant. Sometimes, there is too much water and sometimes there is too little water.
- Its distribution is not even and differs from one place to another (spatial) and from one time to another (temporal).
Part 2: Water is a renewal resource

Time for the replacement of waters

Scientists have been successful to provide approximate data on the distribution of water in the Earth. Table 1 indicates that water can be found in different locations. Data should be considered as indicative only, but provide the basis for other considerations. For example, lakes require 10 years to replenish their waters. However, most of the lake water is stored in a few great lakes, where the rate of exchange may be more than 10 years. One-quarter of the total lake waters is stored in Lake Baikal (Russia), Lake Tanganyika (Africa) and Lake Superior (US and Canada).

Hydrological cycle

Table 1: Water resources, volumes and replacement time

<table>
<thead>
<tr>
<th>Location</th>
<th>Volume (In million)</th>
<th>Time required for replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oceans</td>
<td>1,370</td>
<td>2,600 years</td>
</tr>
<tr>
<td>Groundwater</td>
<td>60</td>
<td>5,000 years</td>
</tr>
<tr>
<td>Glaciers</td>
<td>24</td>
<td>10,000 years</td>
</tr>
<tr>
<td>Lakes</td>
<td>0.23</td>
<td>10 years</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>0.07</td>
<td>11 months</td>
</tr>
<tr>
<td>Vapor</td>
<td>0.014</td>
<td>10 days</td>
</tr>
<tr>
<td>Rivers</td>
<td>0.001</td>
<td>12 days</td>
</tr>
<tr>
<td>Total</td>
<td>1,454</td>
<td></td>
</tr>
</tbody>
</table>

Source: UNESCO-UNEP IEEP (1992:17)

Water moves around the world from one form to another through a cyclical process. For example, liquid water moves to vapor water (gas form) and vapor water moves to ice, solid water (solid form). The circulation of water from one form to another is called the hydrological cycle.
In other words, the hydrological cycle is a path through which water circulates in different forms in the natural environment. It is a solar energy-driven system. The hydrological cycle, as the phrase designates, has no beginning and end. It exists in an endless cycle, moving between its gas, liquid and solid forms.

The hydrological cycle is the natural method of replenishing, redistributing and purifying the world’s water resources.

**Explanation**

1. When temperature rises, liquid waters from the oceans and the Earth surface (water bodies, landscapes, animals and vegetation) are evaporated as vapors into the atmosphere and later become cloud.
2. At cool temperature, cloud through condensation, changes into liquid form and eventually returns to the oceans and the Earth’s surface in the form of precipitation.

<table>
<thead>
<tr>
<th>Evaporation</th>
<th>Condensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaporation is the process by which water changes into gas form.</td>
<td>This is a process in which vapor (gas water) changes into liquid form.</td>
</tr>
</tbody>
</table>

3. Vegetation, buildings, etc. intercept some precipitation. Some move over the land surface on its journey to the ocean and create rivers, streams, lakes and wetlands. Some may infiltrate into the ground and remain there as underground water (aquifers). Some flow out as springs. Still some seep into streams, or a temporary storage like lake. And some are transported by river run-off to the ocean.

<table>
<thead>
<tr>
<th>Transpiration and infiltration</th>
<th>Precipitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transpiration is a process in which water from plants evaporates into the atmosphere as water vapor. Infiltration is the downward movement of water through soil.</td>
<td>Precipitation is the process in which water falls from the atmosphere onto the land and water bodies in different forms (rain, hailstones, snow and sleet).</td>
</tr>
</tbody>
</table>
4. The hydrological process undergoes various phases such as evaporation, transpiration, condensation, precipitation, infiltration, storage and run-off.
5. It should be noted that
   - The hydrological cycle is a closed system or a plumbing system. It means that there is neither creation, nor destruction of water.
   - The cycle is run by the solar energy.
   - The total amount of water contained in each phase is virtually constant in the environment.
   - The hydrological cycle contains much more water than the water we observe as precipitation, run-off, etc.

However, the hydrological cycle is greatly affected by
   - Urban areas
   - Watershed deforestation
   - Climate change
   - Land-use and land cover change (LULC)
   - Alternation in temperature
   - Rate of soil infiltration
   - Surface and sub-surface flow, etc.

Increasing frequencies and severity of storm and risk of flooding are occurring due to increase in the intensity, duration and quantity of precipitation.

So possible effects include (1) change in water supply, and (2) increased risk of flooding and land instability.
Part 3: Why worry about freshwater resources?

Looming water crisis
The availability of only 0.003 % freshwater, its spatial and temporal variability and its necessity for improving the quality of human life have made a looming water crisis in the world and thus making an irreversible impact on the environment, especially on freshwater resources.

Demographically the world’s population tripled and the use of renewable water resources has grown sixfold.

As a result, the situation of water crisis has shown its manifestations in two areas;

- increasing scarcity, and
- deteriorating quality

This crisis is threatening the very existence of man in the Earth.

Forces driving the water crisis
- High demand of water especially safe drinking water
- Conflict over the development of the large-scale dams and groundwater resources
- Pollutions due to discharge, radiation, contamination and natural calamity.
 Forces such as temporal and spatial variability and acid rain deposition accentuated by climate change.

All these forces have caused a looming water crisis in the world.

Any way to get out of this crisis?
Yes, there are some outlets. It is not late, yet.
1) The availability of freshwater resources is adequate enough globally to meet our current and foreseeable needs if they are managed and developed in a sustainable manner.
2) The present water crisis is a crisis of governance - not one of scarcity. The scarcity of water is a relative concept that should be addressed seriously by taking a cross-sectoral perspective such as looking at a basket of factors - socio-economic, institutional and technical.

However, managing water resources sustainably is not an easy task. It is rather a complex one. The “business as usual” approach is not enough. A U-turn needs to be taken. That is to say, a radical approach of “water is everybody’s business” should be adopted. Managing water is a shared business requiring responsible involvement and participation of each and every actor. This approach enables poor people to improve their livelihoods and reduce their vulnerability.
So, we must manage our freshwater resources sustainably, if we want to get out of this looming water crisis.

**Sustainable Management**

Sustainable management of freshwater is the human use of water in a way that yields optimum benefits to present generations, while maintaining its potentials to meet the needs of future generations.

**As a citizen, how can you contribute?**

This booklet provides you an idea to assess the situation of freshwater resources in your community. Because the problems you are facing in your community are real ones. And they need to be solved immediately because they are bothering you and your community.

So, you can do something to improve the situation of freshwater resources in your community. You may begin your mission by concentrating your efforts on the following.

- Go around your own community to get the first hand experience of water situation.
- Learn the management system of water resources from knowledgeable persons and concerned agencies.
- Organize roundtables and PRA (participatory rural appraisals) on the status of freshwater resources.
- Develop participatory plans using local knowledge, skills and resources with a common goal but differentiated responsibilities.

*Community at action in Cambodia (Photo: M. Takahashi)*
Part 4: Global efforts

Global efforts are underway on the improved management and development of freshwater resources. Major ones are briefly given below.

United Nation (UN) organized the first water conference in 1977 and developed an action plan on the improved management and development of water resources. And, UN has designated 2003 as the International Year of Freshwater. Its objectives are to:

- Increase awareness of the importance of sustainable freshwater use, management and protection.
- Provide an opportunity to accelerate the implementation of the principles of integrated water resources management.
- Use the Year as a platform for promoting existing activity and spearheading new initiatives in water resources at the international, regional and national levels.

UN also runs the World Water Assessment Program on global freshwater resources.

The World Summit on Sustainable Development (WSSD) 2002 has emphasized on the development of an integrated water resources management and water efficiency plan.

Global Water Partnership (GWP) is a network of agencies and institutions to promote “integrated water resource management” in developing countries. It facilitates the exchange of knowledge, experience and practice related to water resources management.

World Water Council (WWC) is an international think-tank for water issues. Its objective is to “increase advocacy for improved water resource management”. WWC has been organizing the World Water Forum (WWF) biennially. The 3rd Forum was held in Japan in March 2003.

European Water Association act as a focal point for the exchange of information related to water and water activities.
Step 2: Experience and evaluate the knowledge

Activities
Activities that allow the participants, not only doing but also thinking and evaluating what they have learnt, should be carried out in this step.
1. Take participants to the sources of water for direct observation and hands-on experiences.
2. Select a watershed area and initiate the discussion on freshwater resources.
3. Brainstorm on social and economic values of water resources.
4. Compare and contrast the advantages and disadvantages of good and bad examples of freshwater resource management.
5. Show direct and indirect benefits of water resources to the community.

Method (s)
1. Split the group into smaller ones and ask them to explore on a certain topic.
2. Organize a group visit to the site.
3. Let them write down their experiences about water sources.
4. Ask them to report to the group.

Output
A practical report of what the participant observed and learnt.
Step 3: (A) Adapt the knowledge for your community

Activities
Participants should develop a plan of action for their own community under the guidance of the facilitator. They should discuss it thoroughly; look at how the concept, idea and knowledge are modified.

Method (s)
1. Split the participants into 3-4 small groups.
2. Discuss about the type of water-managed systems they have in their community, at least one site for each group.
3. Discuss the ways they want to tackle the problem and issues.
4. Develop a tentative guideline for adapting a plan.
5. Regroup them for discussion and sharing experiences.

Output
A general framework for adapting a plan
Step 4: Promote the knowledge

Activities
Participants should be divided into smaller groups to discuss their individual plans on disseminating the idea and information. They should be clear about the target. The plan should be realistic and simple; it should focus on publicity, dissemination, capacity building, advocacy, empowering and others.

Output
A plan of action for dissemination

References


Annex: Teaching outline (for the use of the facilitator)

What is happening to our fresh water resources?

Target and objective
ISSUE: Freshwater resources

TARGET: High school teachers

OBJECTIVE: Provide the basic knowledge on the availability and sustainable management of freshwater resources.

STEP 1: Learn about the issue thoroughly
- Concept & availability of water
- Renewability
- Why worry about it?
- Global efforts

Concept of water
- Liquid
- \( \text{H}_2 + \text{O} = \text{H}_2\text{O} \)
- Fills lakes, streams and rivers
- Indispensable for life

Nature of water
- Superior solvent
- No shape, color, taste & odor
- It is renewable
- It is found in solid, liquid & gas forms
- Expands when frozen

Importance and benefits
- Water is practically everywhere.
- A human body \( = 65 \% \) water
- A tree \( = 60 \% \) water
- A jelly \( = 90 \% \) water
Crucial to socio-economic development
Bloodstream of biospheres
Direct uses
Functions

Theories of water
Water is cheap, abundant and perpetually available.
- It will cover a thick layer of 3 km on the Earth.
- This is the water planet.
- We are on the Earth Island

Freshwater is precious, finite and irreplaceable.
- Ocean water = 97 %
- 35 % salt & 3.6 % solid matters

Not usable for drinking, agriculture and industry.
- Total freshwater = 3 %
- Inaccessible freshwater = 2.997 %
- Easily available freshwater = 0.003 %

A simplified example

An analogy of the Earth water in a water tank
Sources of freshwater
- Rain water
- Surface water
- Underground water

So our main concern is freshwater
- Freshwater is very little (only 0.003 %)
- Not constant
- Uneven distribution
- No water, no future

Time for water replacement
- Oceans 2,600 years
- Ground water 5,000 years
- Glaciers 10,000 years
- Lakes 10 years
- Soil moisture 11 months
- Rivers 12 days
- Atmospheric vapor 10 days

The hydrological cycle
The hydrological cycle
- It is run by solar energy.
- It is a plumbing system.
- It is a closed system. No creation or destruction.
- Total amount of water in each phase is constant.
- It contains more water than we can observe in the Earth.

Why worry about freshwater
- There is a looming water crisis in the world
  - Increasing scarcity
  - Deteriorating quality
- In the 20th century
  - The world population tripled
  - But the use of water grew sixfold
- The development of water resources is not substantial
- Distribution of benefits is not egalitarian.

Forces driving the water crisis
- High demand of water
- Conflicts over large-scale water development
- Temporal & spatial variability
- Climate change & acid rain deposition
- Lack of integrated water policy
- Lack of knowledge and skills
- Hits the poor & vulnerable, first & hardest

Any way to get out of this crisis
- Yes, there are.
- The world has enough freshwater
- The present crisis is a crisis of governance- not one of scarcity
- Must take a U-turn & take the “water is every body’s business” approach
- Adopt an integrated management & development of water resources
- Address it with a cross-sectoral perspective

How can you contribute?
- Assess the water situation of your community
- Organize PRAs and roundtables
- Develop participatory programs
- Educate the people of your community
Global efforts
- UN and water
- International Year of Freshwater
- Global Water Partnership (GWP)
- World Water Council (WWC)
- European Water Association

Step 2: Experience/evaluate
- Self-evaluation of topic, knowledge & relevancy
- First-hand experiences or application
- First-hand exposures
- Integrating theory and practice
- Use of six senses

Step 3: Adapt
- Identify a site of freshwater resources
- Modify information to suit the site and the community
- Make it compatible to your needs
- Think locally and act locally

Step 4: Promote
- Enhance values of freshwater
- Publicity and dissemination
- Demonstration
- Sharing knowledge with others
- Advocacy
- Capacity building
- Empowering … …

Your comments are welcome
- Our assumptions
- The LEAP format
- About the material presented
  - Is it simple and easy to understand?
  - Will it be useful to raise awareness?
  - Does it make a sense?
  - How and where can it be improved?
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