Participatory Groundwater Management

Training kit

By

META Research

http://www.metameta.nl/consultancy.htm

Participatory Groundwater managementment

http://www.groundwatermanagement.org/index.htm

More than 2 billion people worldwide depend on groundwater for their daily supply. Major agricultural economies (North China, South Asia, North Africa/Middle East) depend on groundwater. Yet this positive developments have in many areas come at a price - falling groundwater tables and deteriorating groundwater quality.

In many places Participatory Groundwater Management has a possible important role to play to addresss these issues - alongside other measures. To bring together the scattered experience and to equip persons keen to promote participatory groundwater management this training kit has been prepared.

The training kit consists of 8 main modules, which are complemented by additional modules, exercises and reference material. You can browse to the subject of your interest and explore what there is.

This training kit is also available on **cd-rom**. You can order this - free of charge - at info@metameta.nl

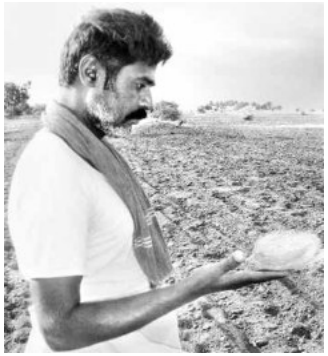
We intend to keep updating this training kit. We therefore welcome any new collaborators! Also, we are interested in your feedback. Contact us at info@metameta.nl

Groundwater KIT:

1. Global situation
2. Hydrology
3. Local regulation
4. Wise use
5. Micro planning
6. Particiatory & monitoring
7. Using laws
8. Awareness

Participatory Groundwater Management

1. Introduction to the Global Groundwater Situation



Groundwater: from Development to Management

Challenge

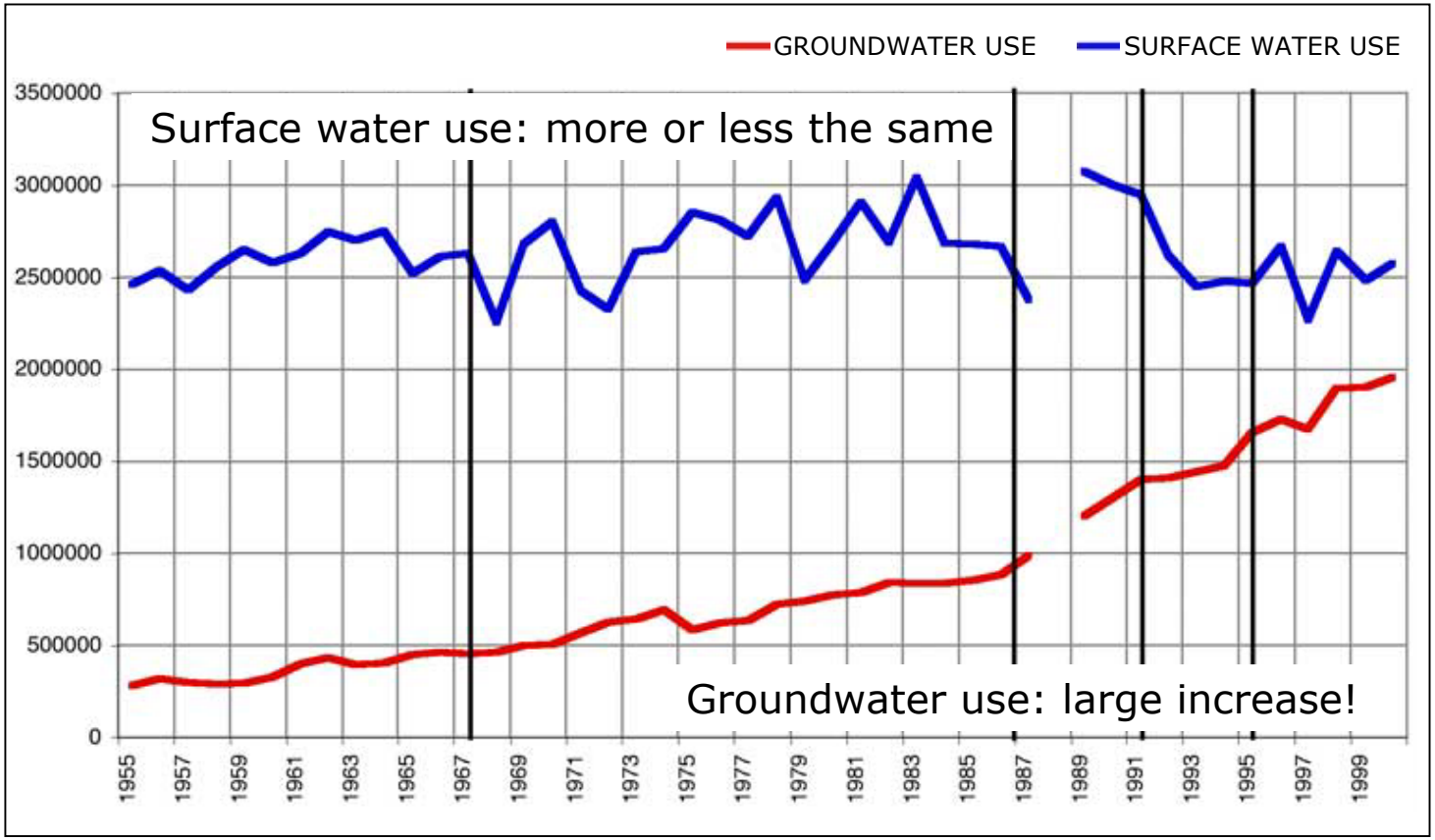
- More than 2 billion people world wide depend on groundwater for their daily supply
- Major agricultural economies (North China, South Asia) depend on groundwater

Much of this is new..

Much of the increase in water use in the world since 1970 is due to groundwater development

Drawing first water in West Bengal, India

Water use in Andhra Pradesh, India:



Fueled by the pumpset revolution

Groundwater development has brought major benefits:

- Food security
- Safe drinking water supply for households and industries
- High value agriculture and horticulture
- Inland fishery
- Flood buffering

But in several areas the miracle is reaching its limits:

- Falling groundwater tables
- Groundwater pollution
- Salinization
- Compaction of aquifers and land subsidence

Some examples…

Yemen –
Sana'a Basin

What is happening here?

Groundwater overuse: Dried-up aquifers

Yemen – Sana'a Basin

Irrigation by tanker

From well at 8 km distance

Mexico

What is happening here?

Mexico

Land subsidence because of falling groundwater


What has happened here?
Pullavolla, Nellore, India

ANDHRA PRADESH

OVER EXPLOITATION OF GROUNDWATER FOR CULTIVATION

RABI 2000-01 mandal wise
177 Mandals in category I
55 Mandals: over 10,000 acres under GW
60 Mandals: 5000 to 9999 acres under GW

Nellore

Acreage under groundwater in Rabi season and in acres

- 5,000
- 10,000
- 25000
- 50000

Categories of mandals
...n Groundwater Department

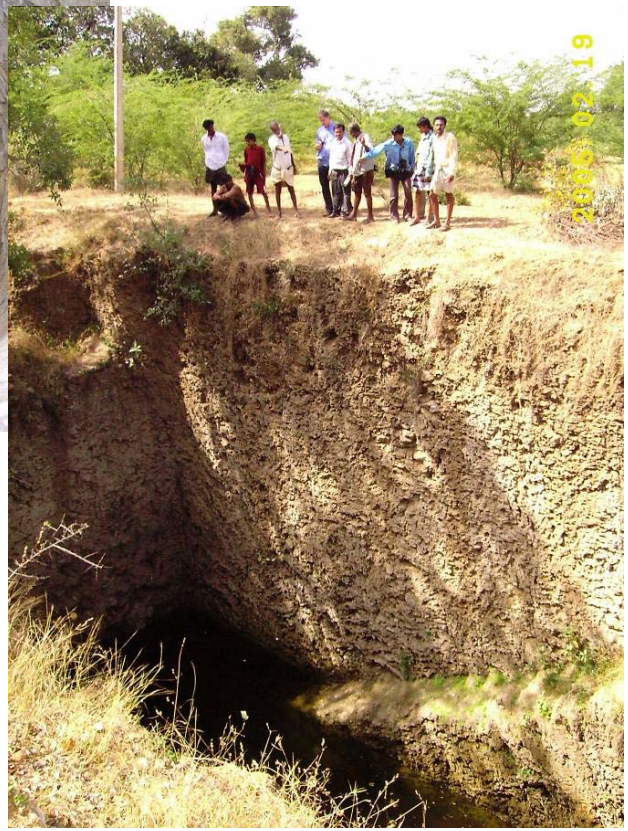
- I Exploitation >100% & Water level >20m
- II Exploitation 90-100% & Water level 15-20m
- III Exploitation 70-90% & Water level 10-15m
- IV Exploitation 50-70% & Water level 5-10m
- V Exploitation <50% & Water level >5m

0 220 km

Map prepared by:
Anne Chappuis

Data source:
DIR OF ECON. & STATS - GROUNDWATER DEPT

VIStA
Visual Information Systems for Action



Empty Shallow Wells

Reliance of deep borewells now..

These have high fluoride levels - between 3.0-3.5 ppm

Pullavolle,
Nellore, India

In 1990 there was a spurt in groundwater exploitation with many new borewells

Water tables dropped and drinking water was obtained from deeper layers

These deeper layers contained high fluor levels

Ever since dental problems, joint problems and kidney defects are endemic in the village

Pullavolle,
Nellore, India

Apart from this misery, effectively the village is stigmatized.

No one wants to marry into the village. No one from the village can marry elsewhere

Guests are afraid to stay the night

Ministerial conference, Kyoto 2003

"Whilst groundwater storage is vast (over 99%) of fresh water reserves, its rate of replenishment is finite and mainly limited to the shallower aquifers, whose quality can also be seriously (and even irreversibly) degraded. Excessive resource development, uncontrolled urban and industrial discharges, and agricultural intensification are causing increasingly widespread degradation of aquifers"

Threats

- Falling water tables
- Pollution
- Quality deterioration because of intense use:
  - Salinity ingression
  - Fluor and/or arsenic contamination
- Land subsidence

A range of measures is usually proposed

Range of measures:

- Registration and regulation
- Awareness campaigns
- Setting up management organizations
- More monitoring
- Zoning
- Buying out wells
- Increase price of using groundwater
- Develop alternative sources of water
- …

All these measures can be supplemented by promoting participatory groundwater management

Participatory groundwater management

=

Management by groundwater users themselves

This will:

Generate local regulating mechanisms

Help find workable packages of measures

Improve acceptance of external measures

This training >>

1 Global Groundwater Situation (this module)
2 Basics of Groundwater hydrology
3 Local Regulation in Groundwater
4 Wise Groundwater Use
5 Promoting Micro Planning
6 Participatory Groundwater Monitoring
7 Making Use of Water Laws
8 Awareness Building

Contributors

Most of the training modules were prepared by F.W.M. van Steenbergen (MetaMeta), but there are several who contributed to the development of the modules: A.A. de Groot (MetaMeta), W. Boehmer (Arcadis), M. Cheebane (Development Alternatives), S Govardhan Das (APFAMGS), S. Dixit (ICRISAT), J. Hoogesteger-van Dijk (Wageningen University), K.V.G.K. Rao (Vision Task Force Andhra Pradesh), G. Lichtenthaeler (GTZ), M. Nooij (MetaMeta), T.M. GowriShankar (Remede), R.W.O. Soppe (WaterWatch), H.M. Sweeris (MetaMeta). Financial support was given from the Interim Support to the Water Conservation Mission, implemented by Arcadis Euroconsult.

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Participatory Groundwater Management

2. Basics of Groundwater Hydrology

Basics of Groundwater Hydrology

1. Terminology
2. Groundwater quality
3. Groundwater flow

1. Terminology

- In groundwater hydrology, several terms are used to indicate groundwater situations
- Terminology is hereafter explained in the context of groundwater management

What is groundwater?

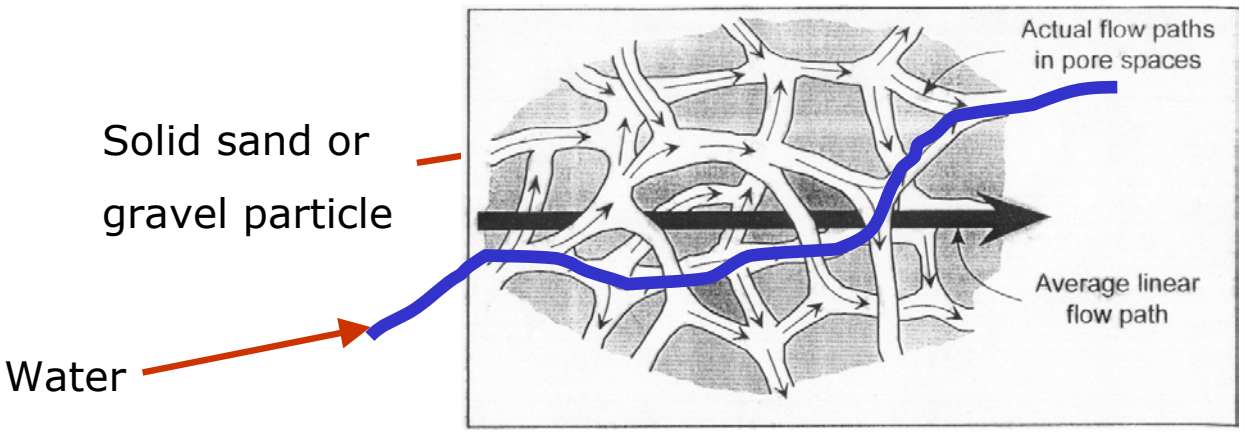
- Groundwater is water that is stored in a porous media (soil/sand/gravel) under the soil surface

Saturated / Unsaturated zone

- The porous media can be fully filled with water, called the saturated zone
- The porous media can be partially filled with water, and partially with air, called the unsaturated zone
- Groundwater management usually only considers the saturated zone (unfortunately)

Misconception

- Saturated zone is not the same as an underground lake
- A groundwater reservoir contains more than only water !

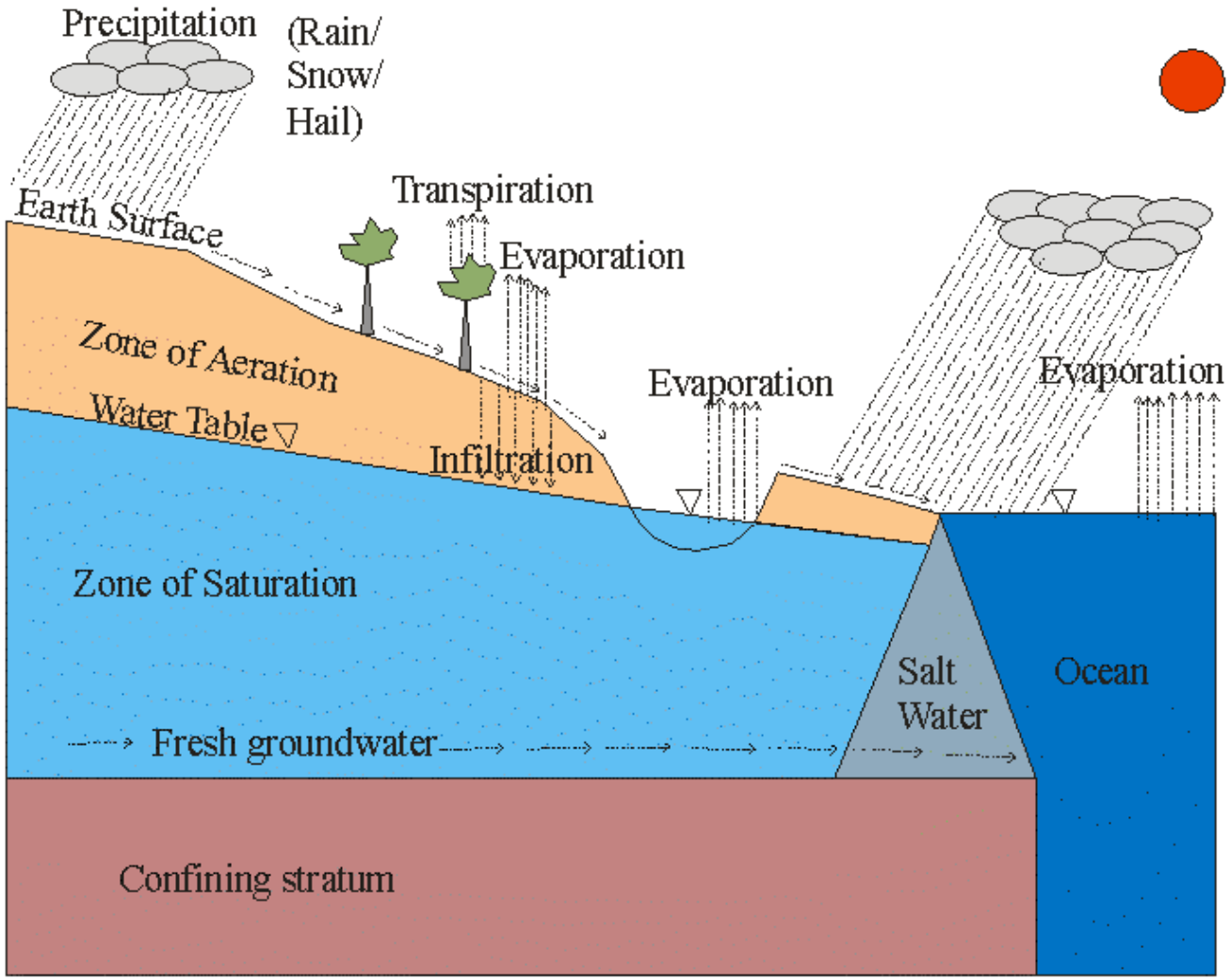


Misconception (2)

- Groundwater is completely different from surface water

NOT TRUE

- Groundwater is part of the water cycle, the same water as surface water !



Earth's Water Cycle or Hydrologic Cycle

Surface water / groundwater

Groundwater usually reacts slower than surface water

- Processes (movement/pollution) usually take more time in groundwater
- RECHARGE and REMEDIATION take therefore much more time !!

Shallow and deep groundwater

Shallow groundwater:

Quick recharge (weeks, months, years)

More prone to outside contamination (organic pollution, effluents)

Deep groundwater:

Slow recharge (decades, centuries, fossil)

Sometimes natural contamination (salts, fluor for instance)

Aquifer

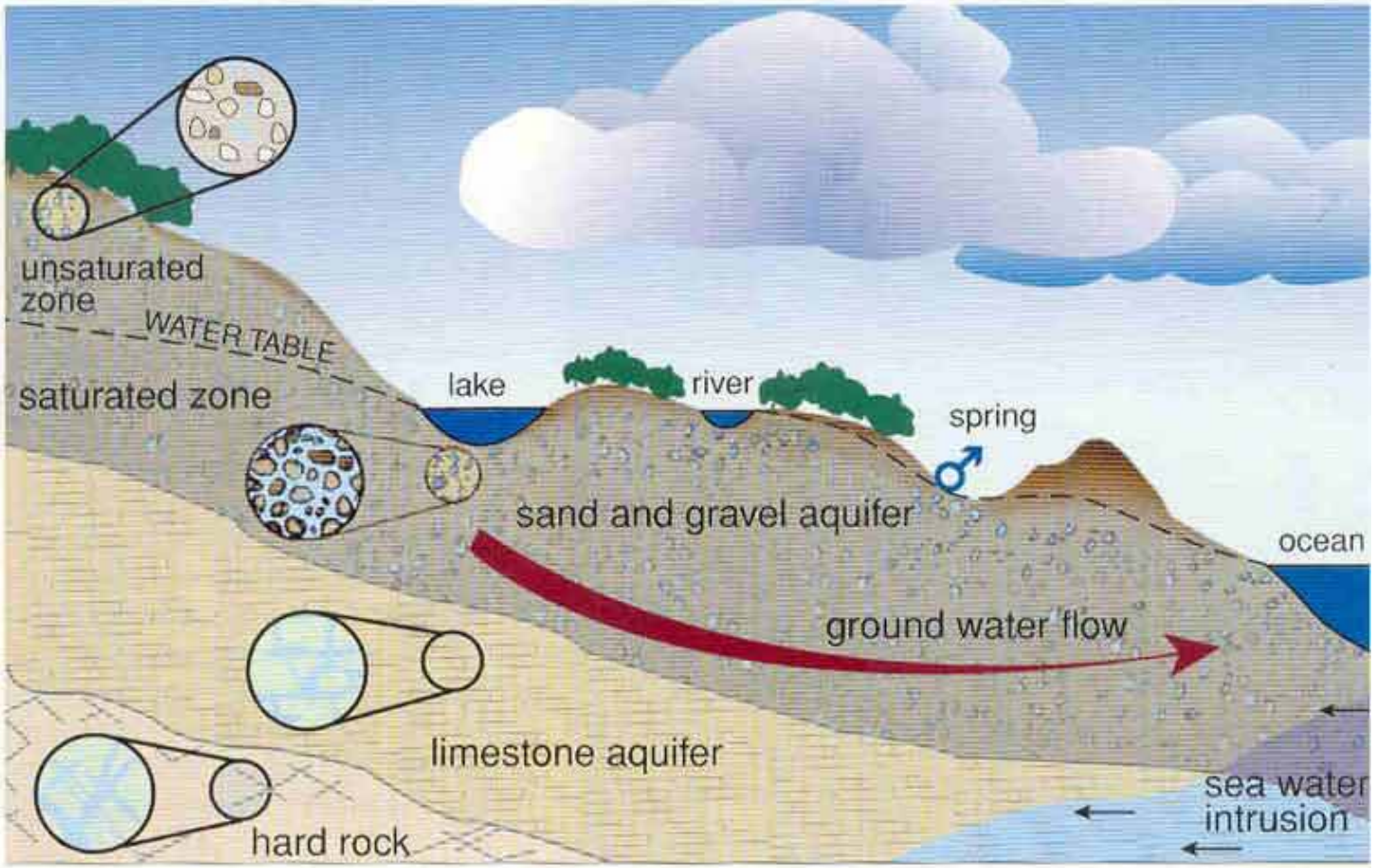
- Aquifer is the "reservoir" of porous media (usually sand, gravel, limestone)
- Aquitard and aquiclude is the name for a confining layer. A confining layer restricts water flow (usually clay or bedrock)

Sponge

A natural sponge on a table:

- The sponge can **absorb** (hold) a lot of water. This is equivalent to an aquifer.
- The table **restricts** water flow. This is equivalent to an confining layer.

Aquifers

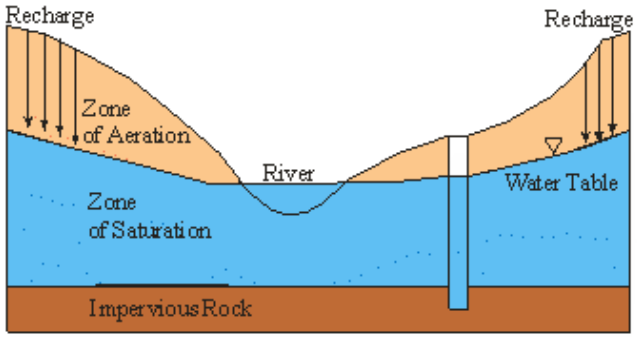

unsaturated zone
WATER TABLE
saturated zone
lake
river
spring
sand and gravel aquifer
ocean
ground water flow
limestone aquifer
sea water intrusion
hard rock

Confined

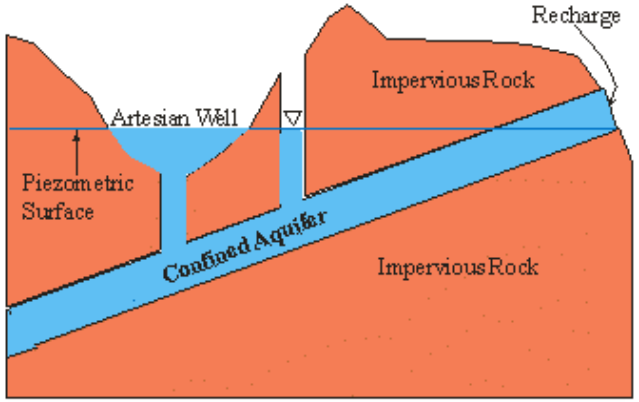
An aquifer can be confined, semi-confined or unconfined

- **Confined**: Groundwater is between two restricting layers
- **Unconfined**: Top of the groundwater is not confined by a restrictive layer
- **Semi-confined**: Groundwater has semi-restrictive layer

Confined and unconfined aquifers



Unconfined Aquifer



Confined Aquifer

Aquifers

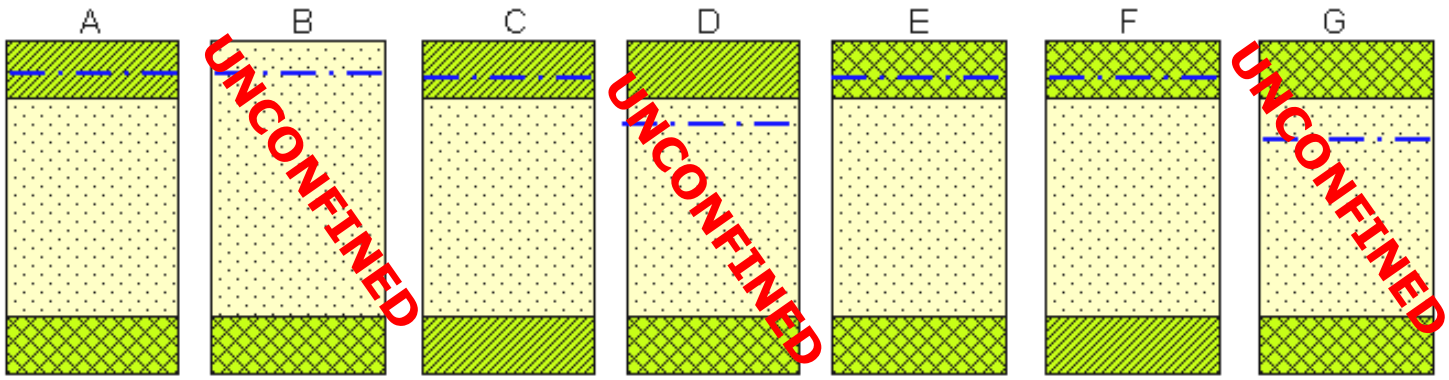
Aquifer

Semi-permeable layer (aquitard)

Impermeable layer (aquiclude or aquifuge)

Top of saturated zone

Analyse the following aquifer systems: confined or unconfined?



Confined aquifers

- Confined aquifer is usually “under pressure”
- Unconfined aquifer is not pressurized

Water table

- Top of an unconfined aquifer is the water table
- Top of the pressure level in a confined aquifer is the phreatic level or piezometric level
- Piezometric level is HIGHER than the actual water level in the confined aquifer !

Water table

- The pressure at the top of the water table equals the atmospheric pressure
- In groundwater hydrology, the pressure at the top of the water table is defined as 0
- Thus: To lift water ABOVE the water table, energy is needed !!

Wells

Groundwater well

- To measure the level of the water table

Piezometer

- To measure the level of the piezometric or phreatic level

Pumping well

- To extract water from the groundwater to the surface (a pump needs energy to lift the water)

Pumping

- A confined aquifer can be pumped without lowering the water level. The pressure level (piezometric level) however will drop !
- Pumping from an unconfined aquifer will drop the water table

Yield

- Safe Yield: Groundwater management terminology, indicating the volume of water that can be pumped from an aquifer in "a sustainable matter"

- Could also be lawyer talk…

Discussion Items

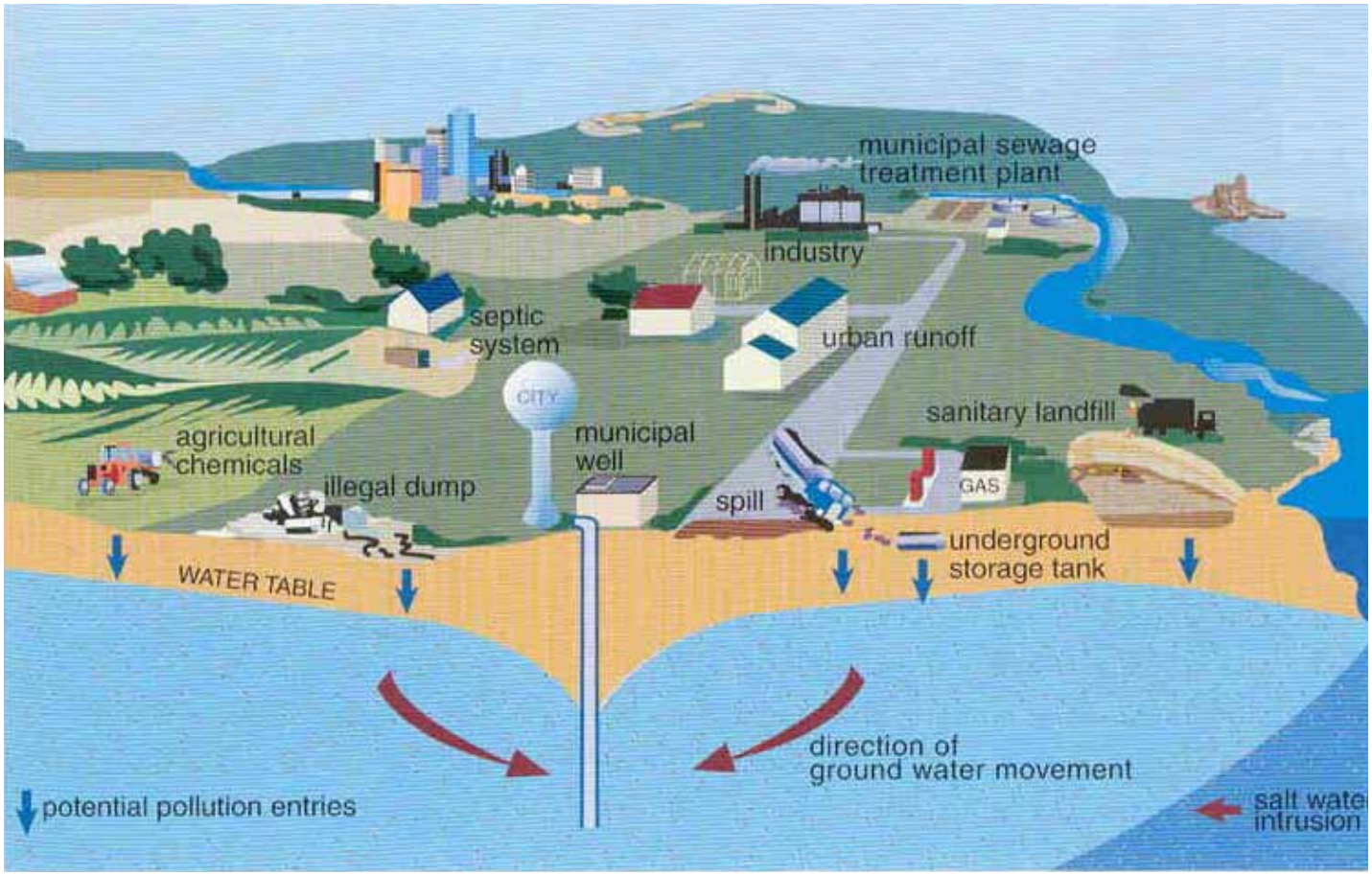
- What are you measuring when the water level in a pumping well is recorded ???
- What is “safe yield” in your groundwater basin ???
- Where does water from a confined aquifer come from ???
- Where is the groundwater reservoir recharged from ???

Groundwater pollution

Many sources of pollution of groundwater:

- Natural contamination (fluoride, arsenic etc)
- Manmade contamination (oil, nitrates, pesticides, caffeine, medicine…)

The causes of groundwater pollution are numerous and are as diverse as the activities of man…



2. Groundwater Quality

- Very important as groundwater is often used for drinking water
- Area of contamination partly depends on speed and mixing rate of groundwater
- Most important effects of reduced quality:
  - More childhood diarrhea and other diseases
  - Less healthy livestock
  - Lower agricultural yield

2. Groundwater Quality

Easiest ways to protect groundwater quality:

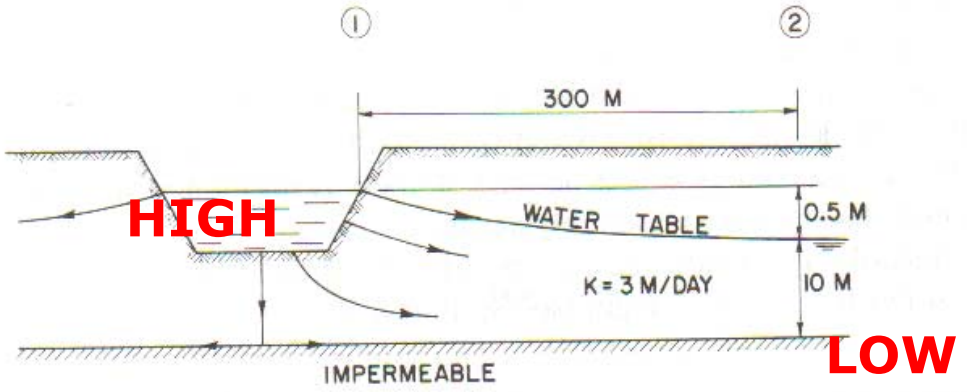
- Protect soil from chemicals/gasoline/oil
- Protect well from animals, children and tap it
- Do not overuse of pesticides
- Keep cooking facilities, body or cloth wash areas and slaughtering areas far from wells
- With high water tables: line latrines and graveyards

Most common mistake

- Don’t let the GROUNDWATER PUMP contaminate the groundwater

3. Groundwater flow

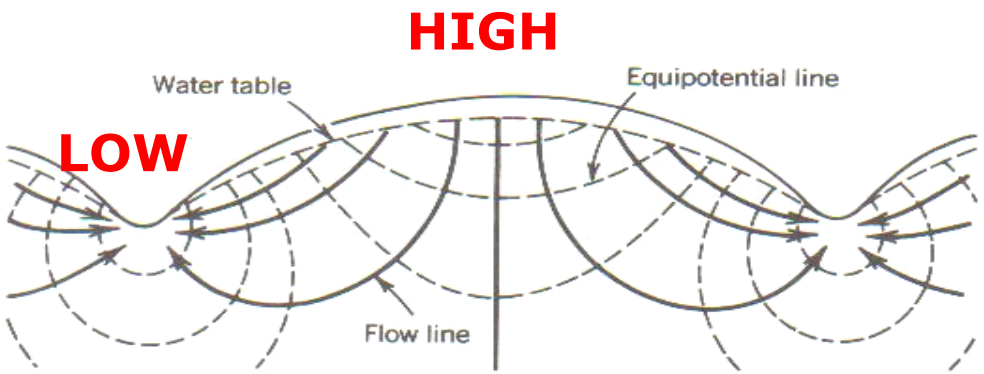
- Groundwater ALWAYS flows from high pressure to low pressure



Seepage from stream in unconfined aquifer with impermeable layer at relatively shallow depth

3. Groundwater flow

- Groundwater ALWAYS flows from high pressure to low pressure. Pollution follows groundwater flow!

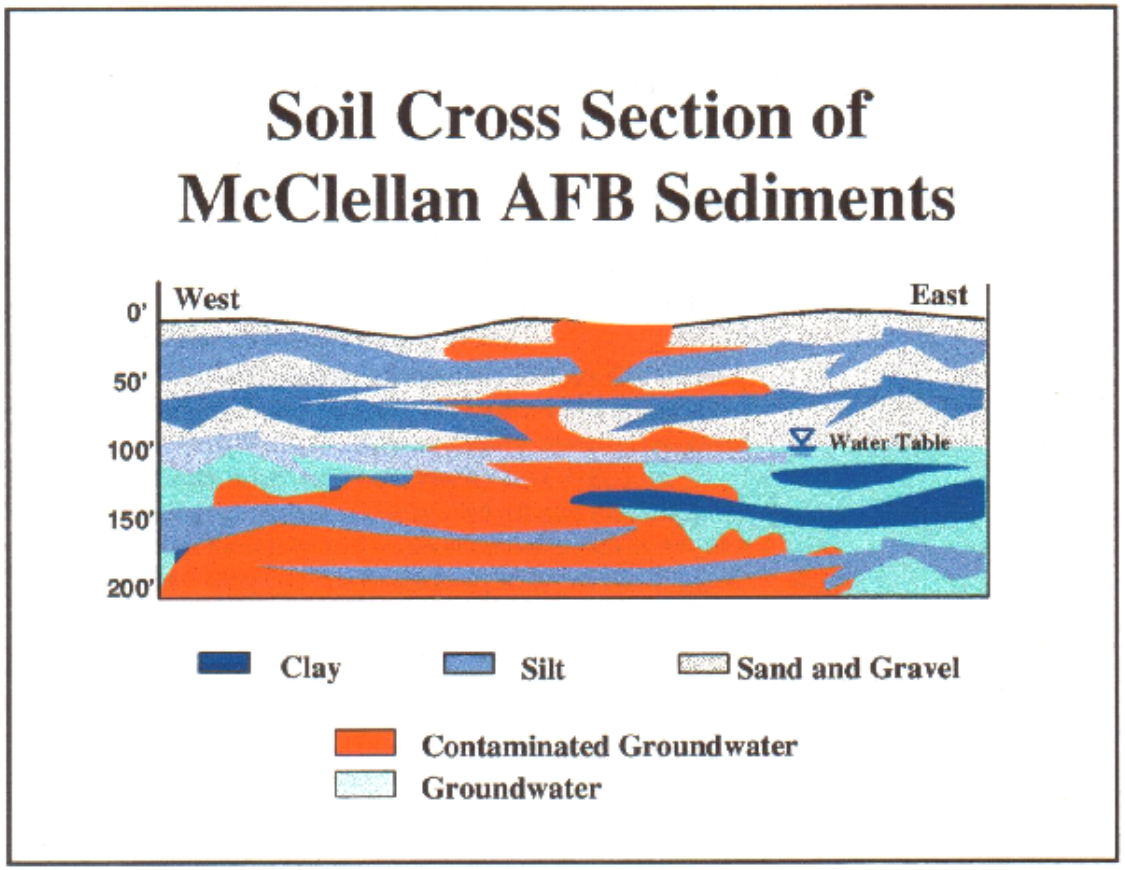


Topographic controlled flow pattern (from Hubbert, 1940). Reprinted by permission of the Journal of Geology, University of Chicago Press. Copyright © 1940.

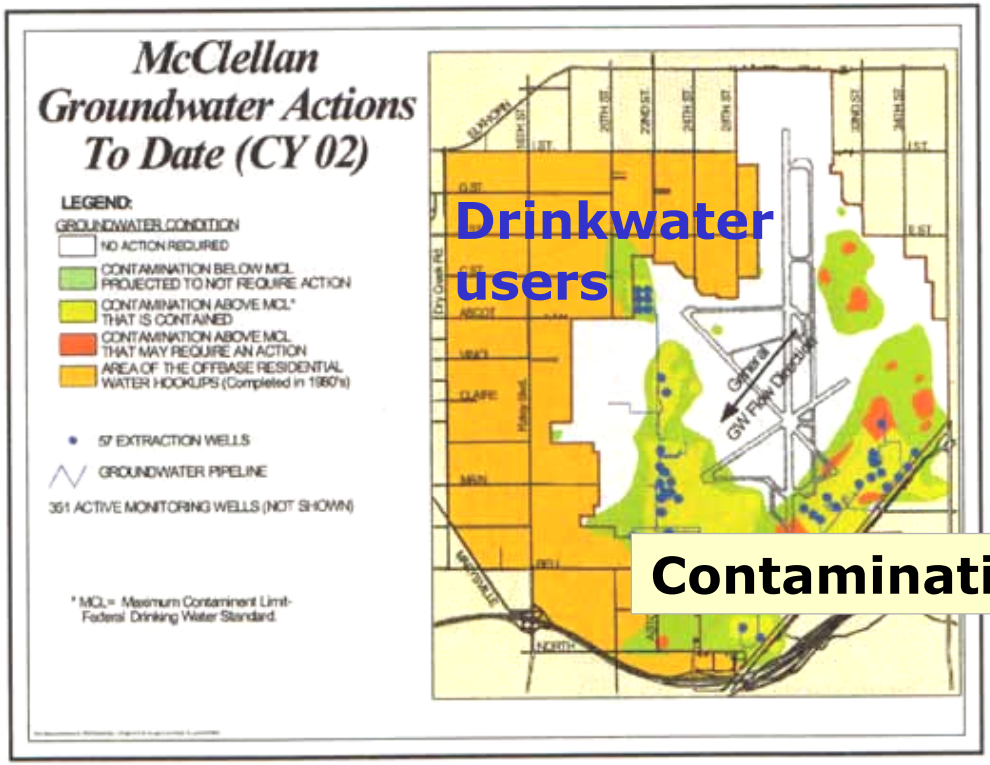
Common mistake

- "Groundwater always flows nicely according to diagrams in books"
- In reality: aquifers are not homogeneous, several aquifers exist from different materials, some are interlinked, real confining layers barely exist…

Groundwater contamination



Groundwater contamination

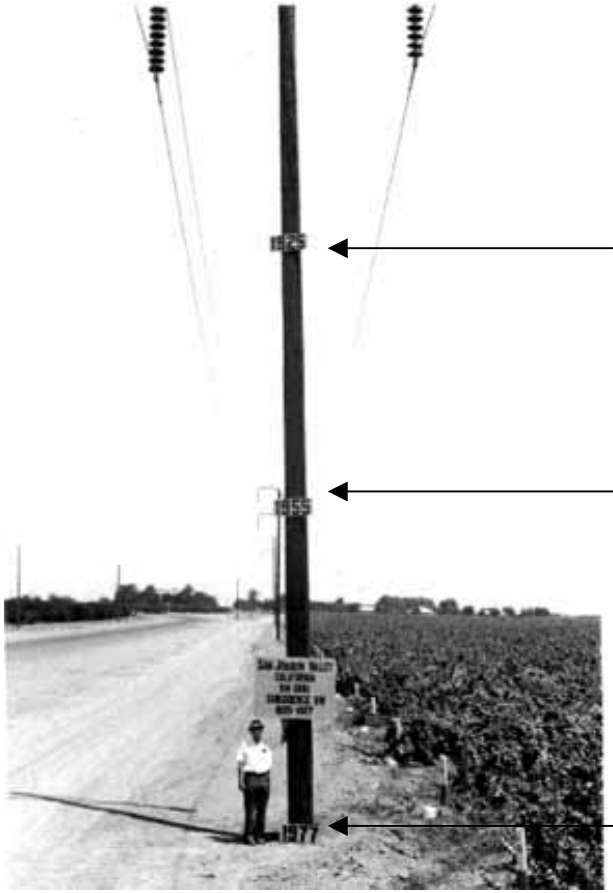


Blue dots are wells for remediation, reversing the groundwater flow

Overdraft

- When groundwater is pumped faster than the recharge, water levels drop
- Porous media lose water, pores are filled with air
- Porous media could consolidate, resulting in land subsidence, sink holes, loss of water storage capacity

Subsidence



land level in 1925

land level in 1955

land level in 1977

Discussion Items

- What affects the velocity of groundwater flow ?
- How is recharge affected by groundwater flow ?
- How to regain groundwater storage capacity AFTER land subsidence ?
- How to remediate groundwater pollution ?
- What are the disadvantages of simplifying groundwater systems to make them fit the diagrams in the books?

Discussion Items

WHY SOLVE GROUNDWATER FLOW? THE REAL LIFE PROBLEM IS NOT EVEN DEFINED!

I have an area with 4 interconnected aquifers with varying thicknesses. Two aquifers wedge out in a clay layer. In Aquifer 3 [illegible] groundwater flow is locally blocked by geological faults. There are clay lenses everywhere in the subsoil. The whole system is sloping. Farmers are pumping from Aquifer 2 and 3 at irregular intervals and rates. There is [illegible] meandering river which sometimes recharges and sometimes drains the groundwater. Heavy rain storms occur during the rain season, at irregular intervals and quantities. Some areas have drainage, others have evaporation ponds. The new irrigation canal is leaking all the time. In Aquifer 4 there is locally saline water.

Could you please give me a formula to solve the groundwater flow??

Presentation prepared by

Richard Soppe

(WaterWatch)

www.waterwatch.nl

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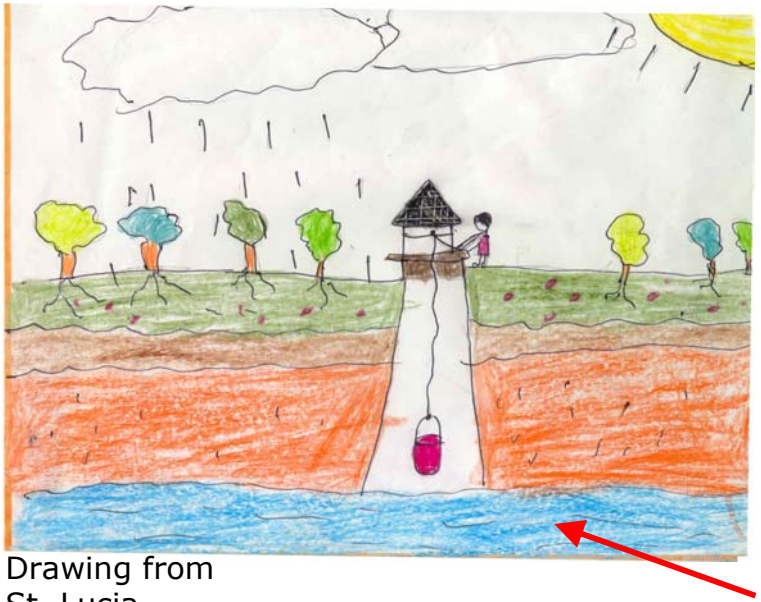
Participatory Groundwater Management

3. Local Regulation in Groundwater Management

The challenge of community groundwater management



Drawing from St. Lucia,

"The lake beneath"

Groundwater users often have no idea how much groundwater there is

A common 'belief' is that there is an underground river or lake that has no limitations.

The challenge of community groundwater management

"Every man his own well"

Most wells are owned by individual families or small groups. So common groundwater management does not come automatically.

The resources are typically shared by very many independent users

Local regulation can help address the lack of groundwater management

Why local regulation?

Reason 1:

In many countries there are large numbers of small ground water users ⏩ This makes is difficult to manage ground water use 'from the top' only. Local regulation is required.

Reason 2:

There is little capacity to enforce in many countries ⏩ Whatever enforcement is there needs to be rooted in local acceptance.

Reason 3:

There is no evidence ⏩ that top down regulation (laws, well registration, user rights and groundwater pricing) on their own have worked anywhere.

What is special about this area (Anantapur)?

Example

No paddy is cultivated here, following a local ban on paddy

Local regulation of groundwater…

- The examples that exist are still few
- They now mainly concern:
  - Shallow aquifers
  - Management of water quantity – not water quality
  - Management of small aquifer systems – not of large unconfined aquifers

Local regulation of groundwater…

- Most examples are ‘home-grown’.
- They have developed ‘against the odds’ without any outside support
- They are in most cases the only thing that worked

Promoting participatory groundwater management is now the need of the day

A number of examples

- Panjgur - Balochistan, Pakistan
- Saurastra - Gujarat, India
- Salheia - East Delta, Egypt
- Guanajuoto, Mexico

Balochistan, Pakistan

- Arid to semi-arid area
- Tribal society
- Long tradition of groundwater use:
  - Vertical wells (karezes) and persian wheels

Balochistan, Pakistan

- These collapses after pumps were introduced:
  - Dugwells replaced karezes
  - Next tubewells replaced dugwells
- Groundwater Rights Administration Ordinance announced in 1978

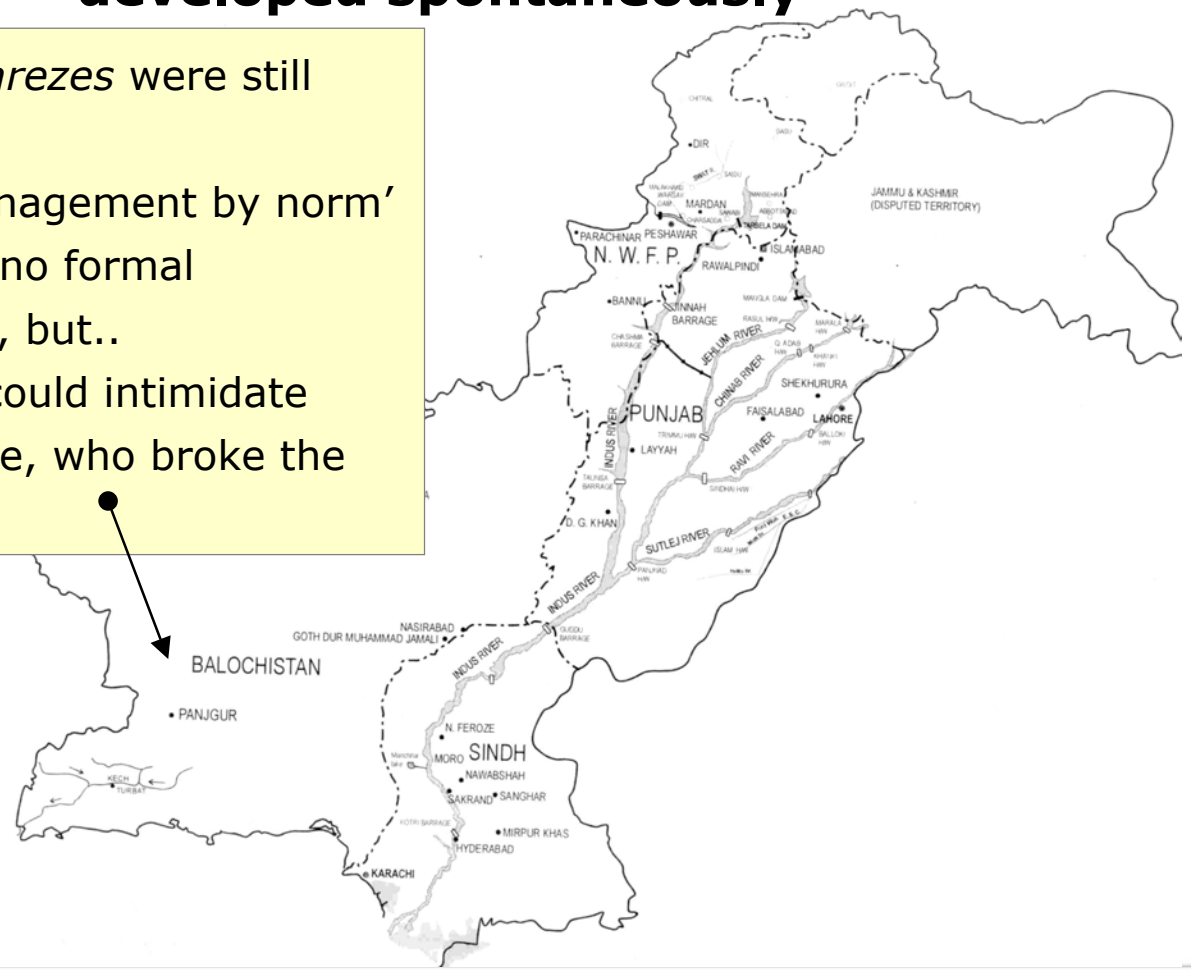
In two areas local regulation developed spontaneously

Case 1 Panjgur

- Water users observed the groundwater decline in neighbouring valleys
- An unspoken 'all-out' ban on dugwells and tubewells developed in Panjgur

In two areas local regulation developed spontaneously

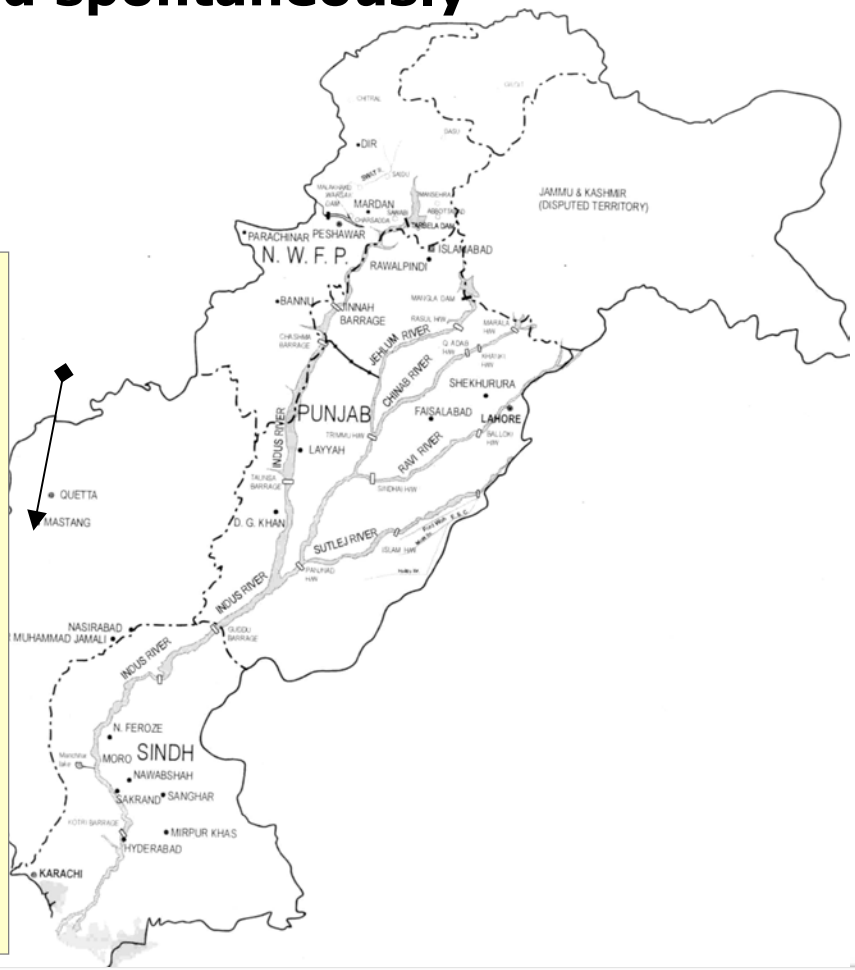
- But new *karezes* were still allowed
- It was 'management by norm' – there was no formal organization, but..
- Everyone could intimidate someone else, who broke the ban



In two areas local regulation developed spontaneously

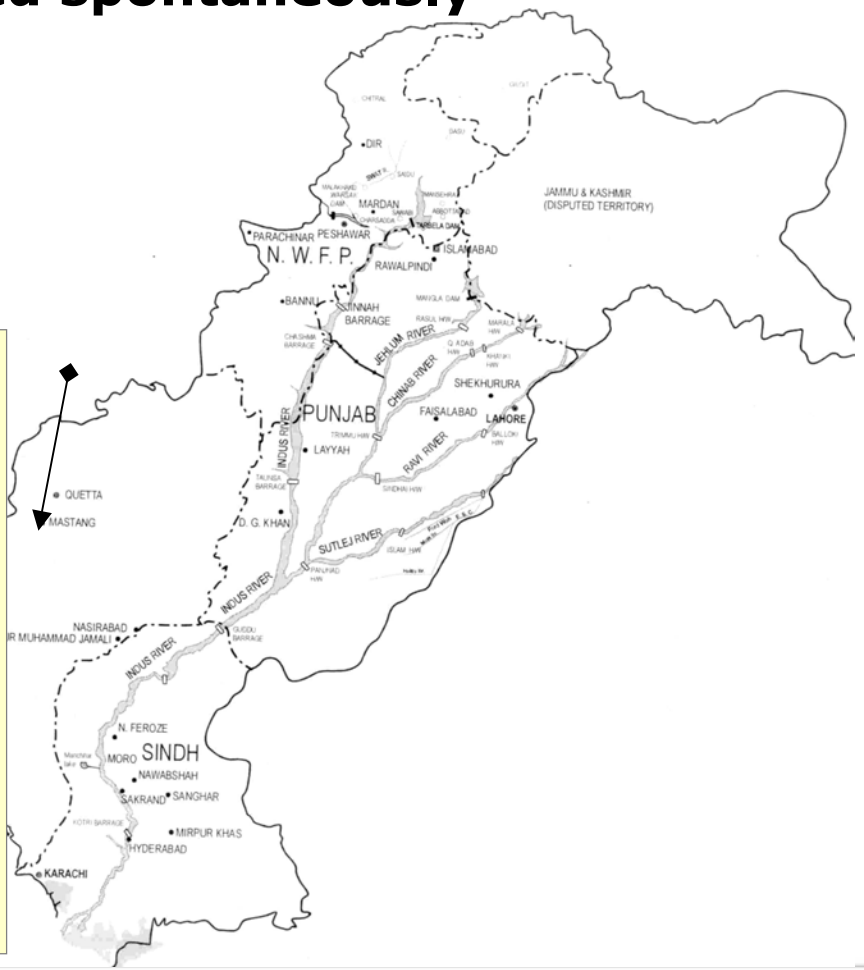
Case 2: Mastung

- After a dry cycle water karezes came close to drying
- At initiative of local government zoning and minimum distance rules were discussed and agreed by local leaders
- This was enforced by local administration



In two areas local regulation developed spontaneously

- But these rules were not restrictive enough
- Karezes were still falling dry
- The critical mass of supporters for the rules waned
- All those who could develop a well did so in the end…



Saurashtra – Gujarat, India

- Widespread decline in ground water
- This resulted among others in fluorosis
- Aggravated by 1985-87 drought
- Recharge movement started - inspired by Hindu leaders, diamond merchants and NGO's

Saurashtra – Gujarat, India

- Simple often individual water harvesting techniques were promoted – sink pits, small check dams
- These isolated experiments were successful

Saurashtra – Gujarat, India

- Entire communities adapted water harvesting measures – this had a noticeable impact
- Success breeds success
- Movement takes off – 95,000 wells recharged in 1992-6
- In several areas rules put in place regulating groundwater use

Salheia - East Delta, Egypt

- Small investors bought land at fringe of canal command area
- They found themselves competing for shallow groundwater
- One water user – engineer by background – took the initiative for a joint hydro-geological survey

Salheia - East Delta, Egypt

- After this farmers decided to turn the individual wells into a common network
- A water users association was established
- This association regulated groundwater usage
- It also successfully lobbied for canal supplies

Guanajuoto - Mexico

- Agricultural economy depends heavily on export to USA using 'clean' groundwater
- Intense groundwater use by urban, industrial and agricultural consumers
- In 1990's the then Governor took the initiative to set up 'Technical Groundwater Committees' (COTAS) – representing the different user groups

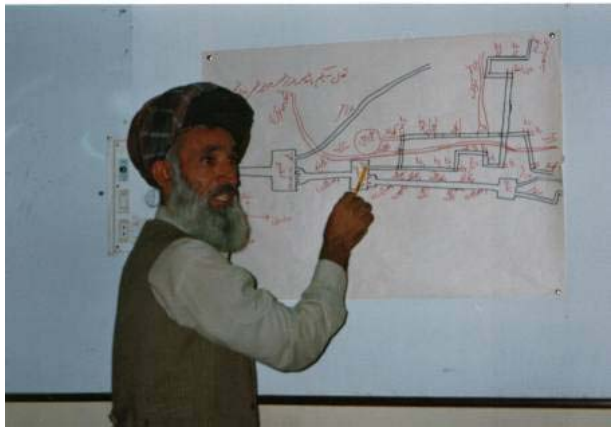
Guanajuoto - Mexico

COTAS:

- Promoting water saving and waste water reuse
- No regulatory powers and remained advisory bodies
- Overuse continued; wells were retro-actively sanctioned by central government

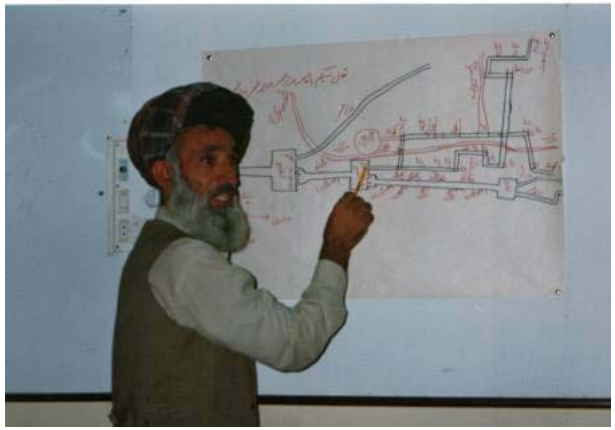
What do the cases tell us?

- Successes and failures
- Where it worked, it was the only thing that did
- Formal organization is useful but not essential
- Importance of correct information



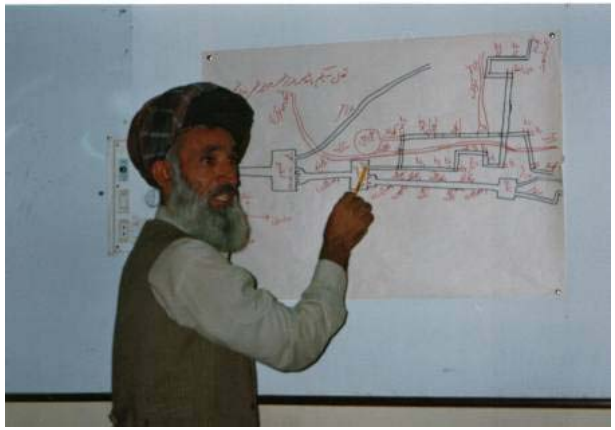
What do the cases tell us?

- In all examples no one is excluded from using groundwater
- Local regulation is easy to get going
- But there are limitations:
  - The do's and don'ts are somewhat inflexible
  - More complex actions demand organizations



What do the cases tell us?

- No one was put out of business
- Local regulation triggers mitigating measures that were not used earlier
  - Recharge
  - Low cost drip
  - Soil moisture improvements
- Such mitigating measures are driven by other factors too – e.g. cost saving, convenience



What do the cases tell us?

Simple rules work best!

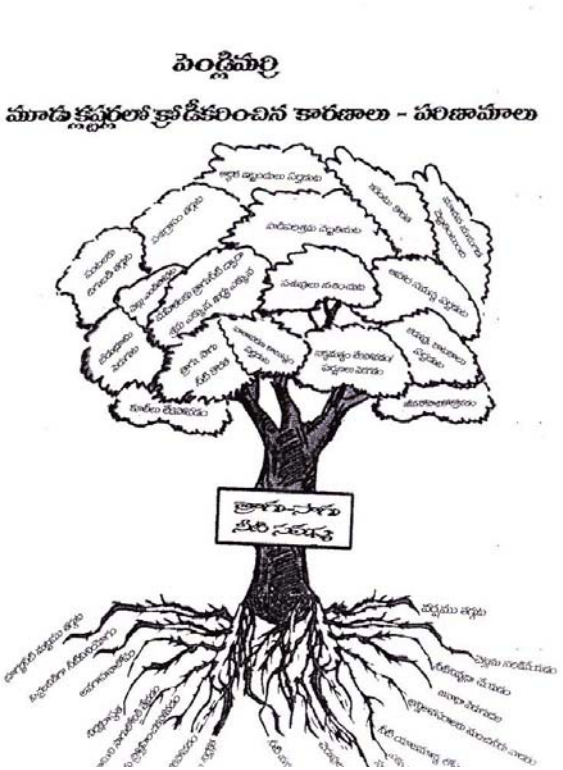
What do the cases tell us?

For instance:

- No tubewells, only open wells
- Minimum distance between wells
- 'No well' zones
- Maximum depth for wells
- Wells only for drinking water
- No family to have more than 1 well
- No pumping for agriculture in part of the year
- Bans on certain high-water consuming crops (for instance paddy in dry season)

The importance of getting local management going..

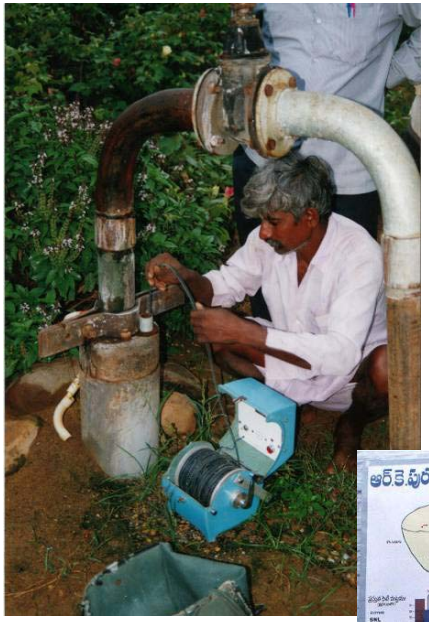
How? Microplanning for instance



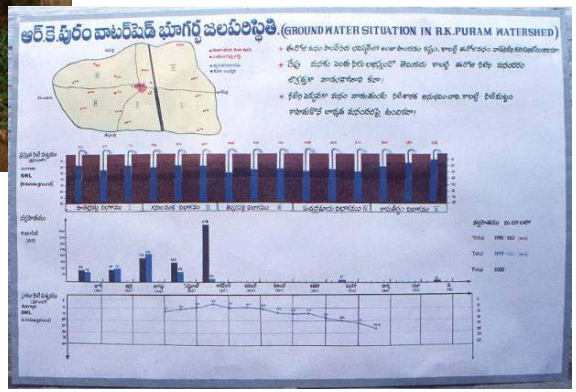
Creating awareness by Problem Tree Analysis

Local agenda setting by encouraging micro water management planning

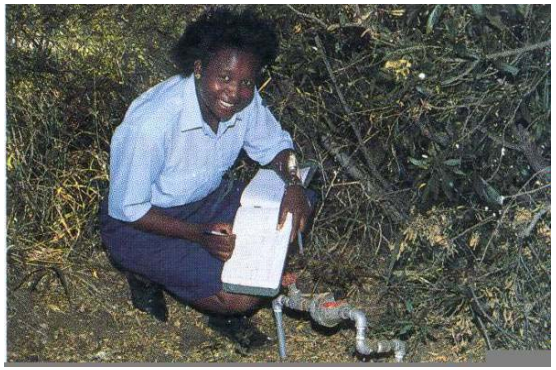
How? Participatory hydrological monitoring for instance



- 'New' unknown resource
- Information is driving force
- Farmers trained to measure water tables, rainfall and make water balances
- Make hydrology less esoteric



Lessons



- Focus on rules – not on 'rights'
- Awareness raising to cast the net wide and find local champions
- Make hydrological science accessible to the real stakeholders
- Promote supply and demand management options
- Promoting local regulation should be linked to watershed improvement programmes and rural water supply programs
- Supported by enabling legislation
- Make more of local water quality management

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Participatory Groundwater Management

4. Wise Groundwater Use

Wise groundwater use

- There are in most cases many measures to rebalance groundwater demand and supply
- Often these measures are not (fully) utilized
- But if they are implemented, they can help to maintain the level of water services without causing overuse!

This module discusses several such mitigating measures

Mitigating measures

- **Supply measures** – measures that augment local groundwater supply
- **Demand measures** – measures that reduce the demand for groundwater and/or facilitate more efficient use of water

Supply measures

- Water harvesting measures
- Water retention measures
- Protecting natural recharge

>>Preferably these are implemented at sufficient density so that the results become noticeable<<

Water harvesting measures

Measures that capture rainfall and run-off and store it in the soil profile or add to the recharge

Examples of water harvesting measures

- Recharge wells
- Percolation ponds
- Contour bunding
- Checkdams and gully-plugs
- Subsurface dams

By channelling run-off to disused dugwells, recharge wells are created

Example:
Recharge well

Example: Retention Weir

The water

This slows down run-off, raises the water table and increases recharge

Because of the weir in this drain water is retained in the area

Example 2: Retention weir

This helped recharge wells.

This weir in Maharastra in India was built to increase water levels upstream of the weir.

Point of attention

- There is a **large variety** of water harvesting and water retention structures all over the world – following local terrain, rainfall pattern and local tradition and skills
- **Maintenance** is very important – of structures and to remove silt from recharge beds

Point of attention

- Water harvesting and water retention will reduce flooding risks but may also affect **downstream availability** of water

  This **impact** needs to be considered!

Safeguarding natural recharge

One also needs to make sure that the natural recharge is safeguarded

In particular:
Avoid that sand mining destroys the beds of local streams and rivers

Avoid damage to the river bed

- Indiscriminate sand and gravel mining affects groundwater availability
  - It lowers drainage lines in the area and induces more outflow from the aquifers
  - It destroys the capacity to store water in the sand of the river bed and recharge local groundwater resources
  - Because of sand mining rivers will flood more sharply
- Sand and gravel mining therefore need to be regulated

Example: because of sand mining...

However..
This community stopped sand transport by visiting trucks

It excavated a trench so that trucks cannot enter the river anymore. It also employed two guards.

Demand management measures

These reduce the demand
for groundwater

More efficient water application

Efficient field irrigation – f.i.

- Landlevelling
- Field bunding
- Drip irrigation
- Sprinkler irrigation

Better soil moisture conservation

- Use of compost
- Mulching
- Ploughing

Example: Field bunding

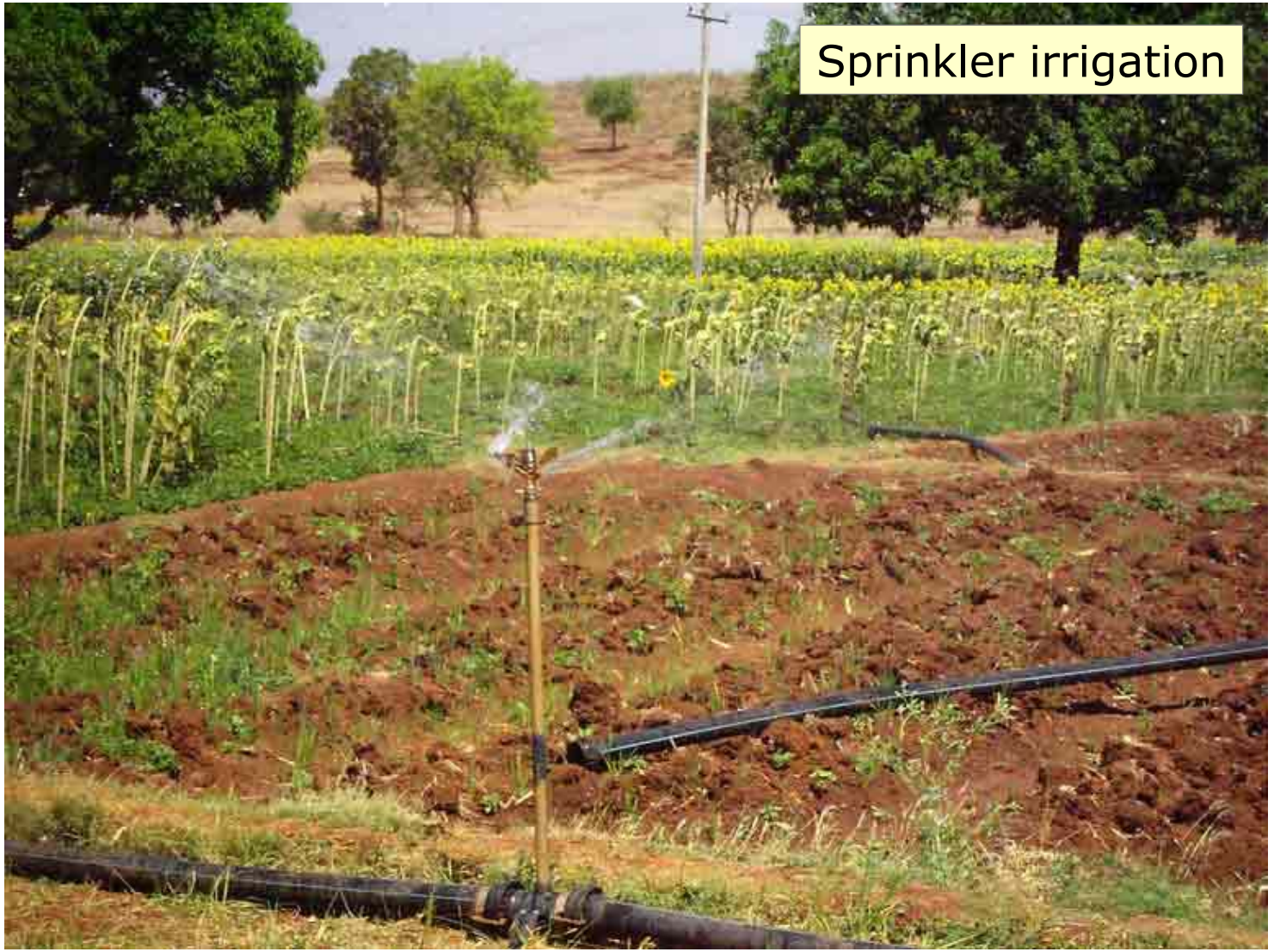
This retains water
in the field
And makes sure
that water is
spread evenly

Example: Tree bunding

Bunding around individual tree crops

Drip irrigation

- Used for horticultural crops and cotton
- Irrigation efficiency up to 90%
- Can be used for fertigation too (application of fertilizers in irrigation waters)
- Price USD 300-400/ha
- Low cost options also available



Sprinkler irrigation

Points of attention

- The challenge is to promote micro irrigation through local sales not through government 'give-aways'
- If irrigation is more efficient though – this also means less seepage and less recharge

Better soil water retention

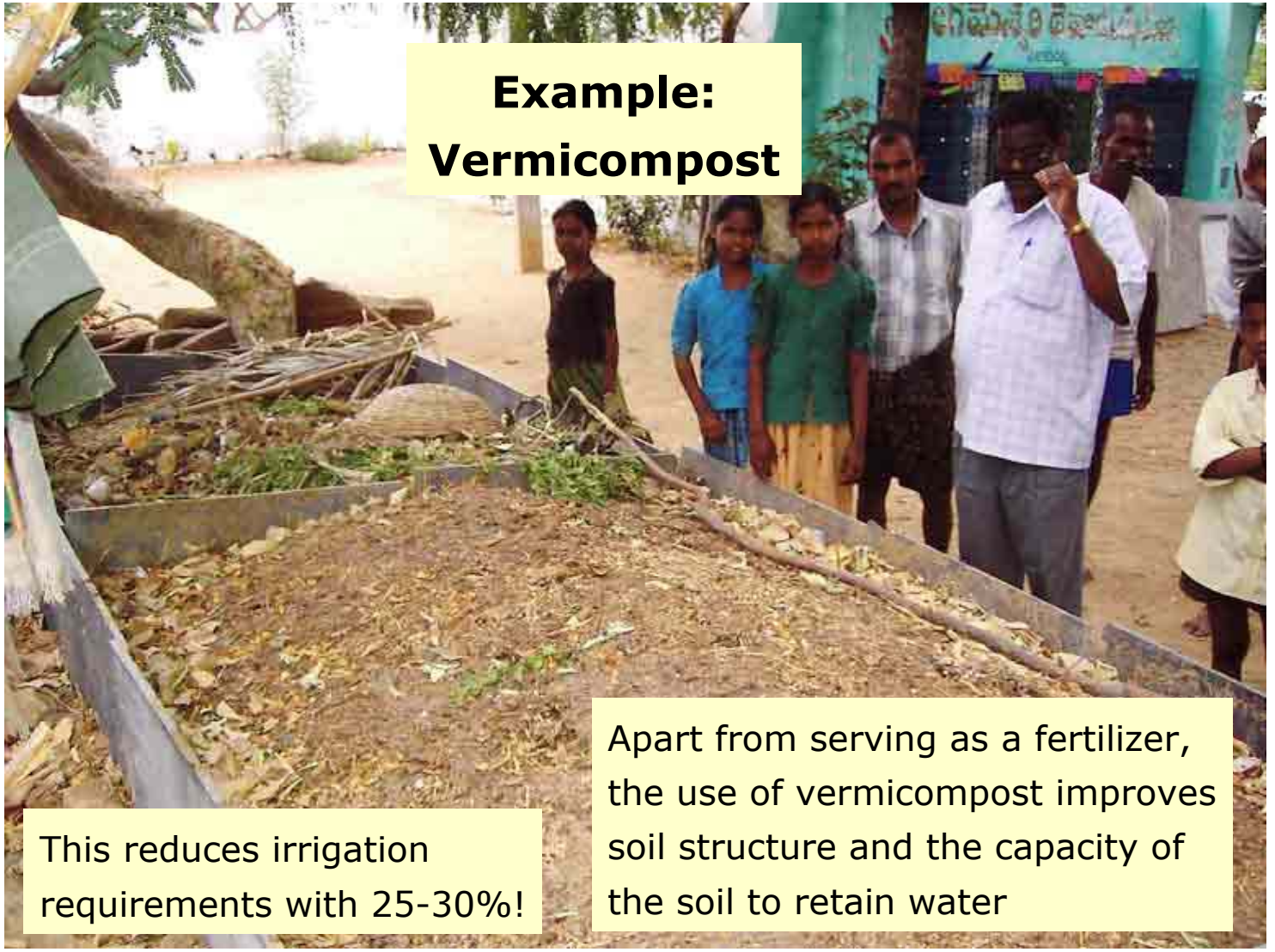
Use of organic material will improve the soil structure and the capacity of the soil to retain moisture

Organic material can include:

- Cowdung
- Compost/ vermicompost
- Leaves

Example: Vermicompost

Organic waste is fed to worms to create compost



Example: Vermicompost

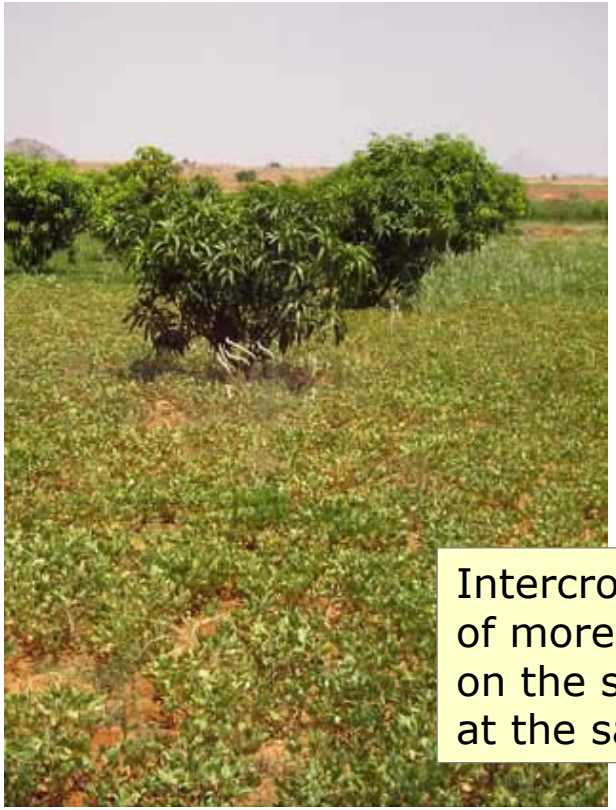
This reduces irrigation requirements with 25-30%!

Apart from serving as a fertilizer, the use of vermicompost improves soil structure and the capacity of the soil to retain water

Example:

Using dried palm leaves to retain water in the soil

Changing cropping systems to reduce water demand



- Change to profitable low water use crops
- Use more water efficient farming systems

Intercropping (The growing of more than one species on the same piece of land at the same time)

Over the years food habits have changed and more water demanding crops have become popular

Less water demanding crops need to be promoted

Example: Growing groundnuts instead of paddy!

Example:

System of Rice Intensification

introduces more water efficient cropping system

Conclusion

- Even in areas where there are considerable differences between groundwater recharge and groundwater exploitation several **mitigating measures** are possible to restore the balance

- Many of these measures have **additional benefits** too

Challenge!

Unless there is regulation of groundwater use, these measures will not lead to sustainable groundwater use

Challenge!

The challenge is to promote **spontaneous investments**, for instance in simple local water harvesting and micro-irrigation

If people themselves invest in demand and supply measures, they will also want to invest in **local regulation**

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Participatory Groundwater Management

5. Promoting Micro Planning

Micro Planning

This case is based on capacity building under the Water Conservation Mission in Andhra Pradesh

In this program:
970 villages prepared a micro plan approved by local government over a period of eight months
With the help of 13 NGO's

In 98% of the plans local regulatory measures were identified
In 94% local investments were identified

Why Micro Planning

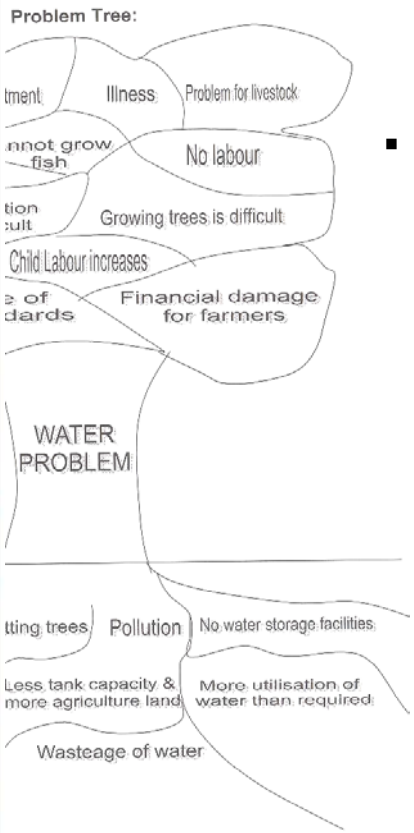
- To put local groundwater management on the agenda
- To identify measures – both in local regulation and local investment
- To create 'peer' effects

Promoting Micro Planning – how?

Three steps:

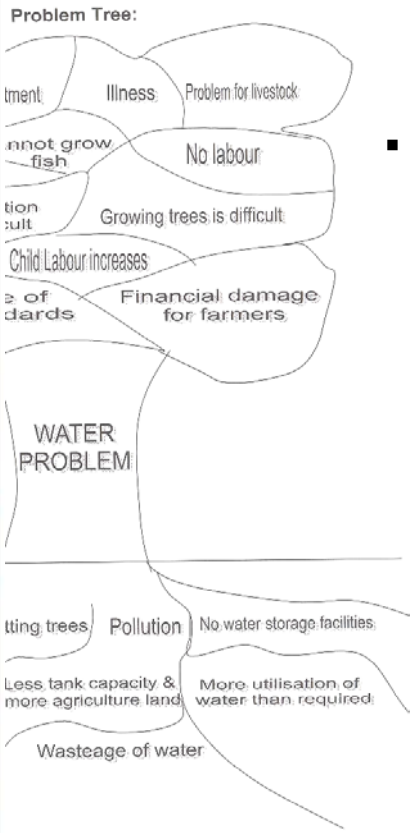
- Raising awareness
- Preparing action plans
- Creating peer network

Creating awareness



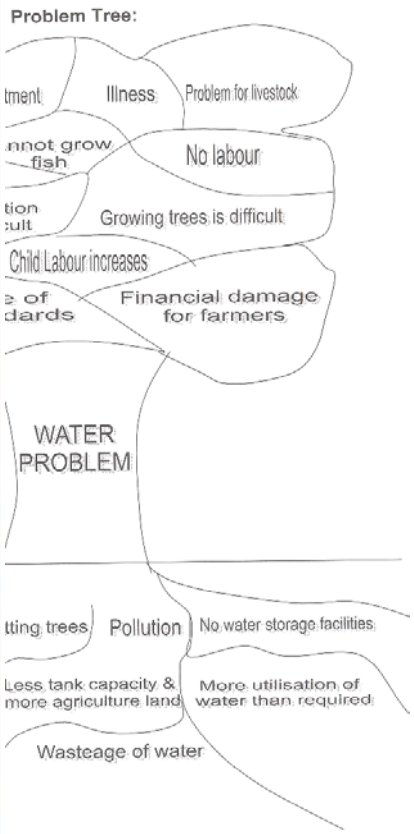
- One day training:
  - Problem tree analysis
  - Games
  - Discussion on legal and institutional arrangements as they formally exist

Important



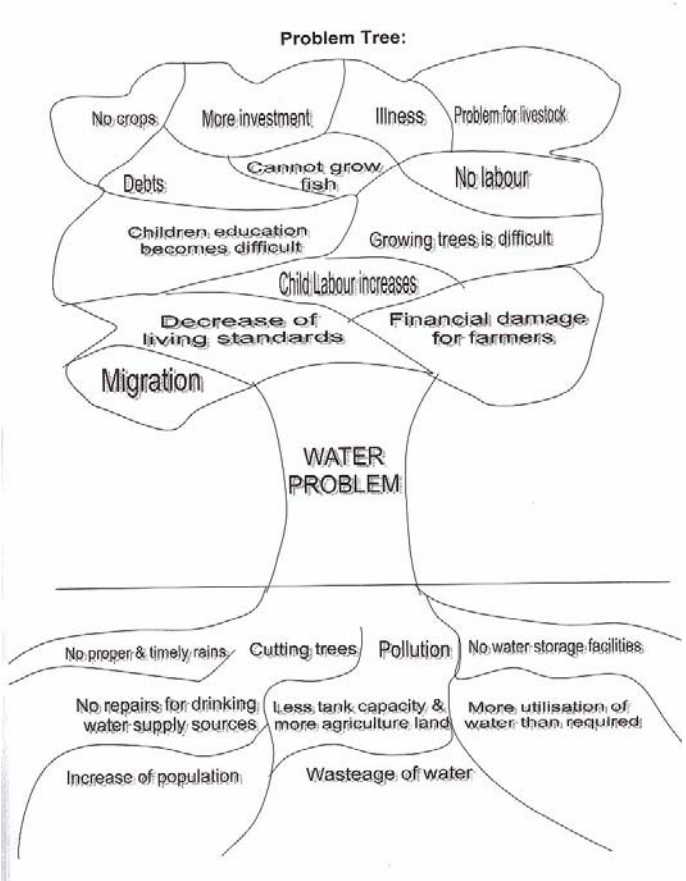
- Whom to invite?
  - Those who matter
  - Men and women
  - What status to give to the training?
  - Plan to be endorsed

Problem tree analysis



- Jointly identify water related problems
- Formulate them clearly
- Identify how they are linked – causes and effects
- Identify solution tree by reversing problems into solutions

Problem tree

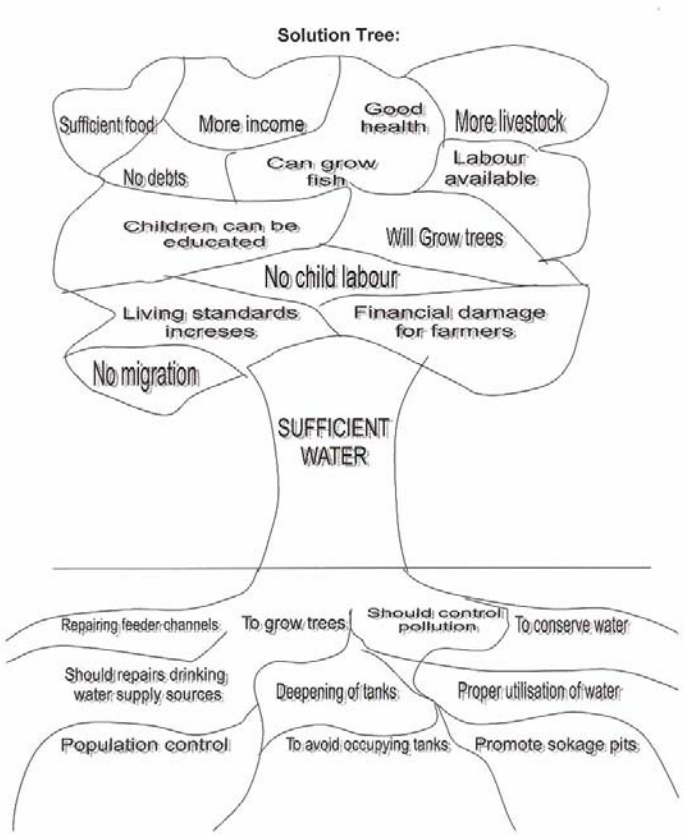


Problem tree analyzes causes and effects

7. Group discussion of men members on "problems tree"

Solution tree

And leads to solution tree



Legal and institutional awareness

- Many legal provision and institutional arrangements exist
- But usually no one knows - so no one will use
- So explain to water users what legal instruments they have

Step 2: Micro Planning

- Suggested program
  - Refresher of awareness building
  - Transect walks
  - Trend analysis
  - Participatory water budgeting
  - Resource map
  - Micro planning

Transect walk

- Systematic route through the area
  - Stop at each water point, structure or gully
  - Stop at each drinking water/ sanitation facility
- Making observations at all water points
- Summarize findings

Transect walk

Trend analysis

- Discuss with group situation now and in the past
- Take 3-4 points in time and discuss:
  - Population numbers
  - Livestock numbers
  - Type of crops
  - Type and number of wells
  - Condition of tanks, terraces and other structures
  - Depth of water table
  - Quality of water

Trend analysis

Resource map

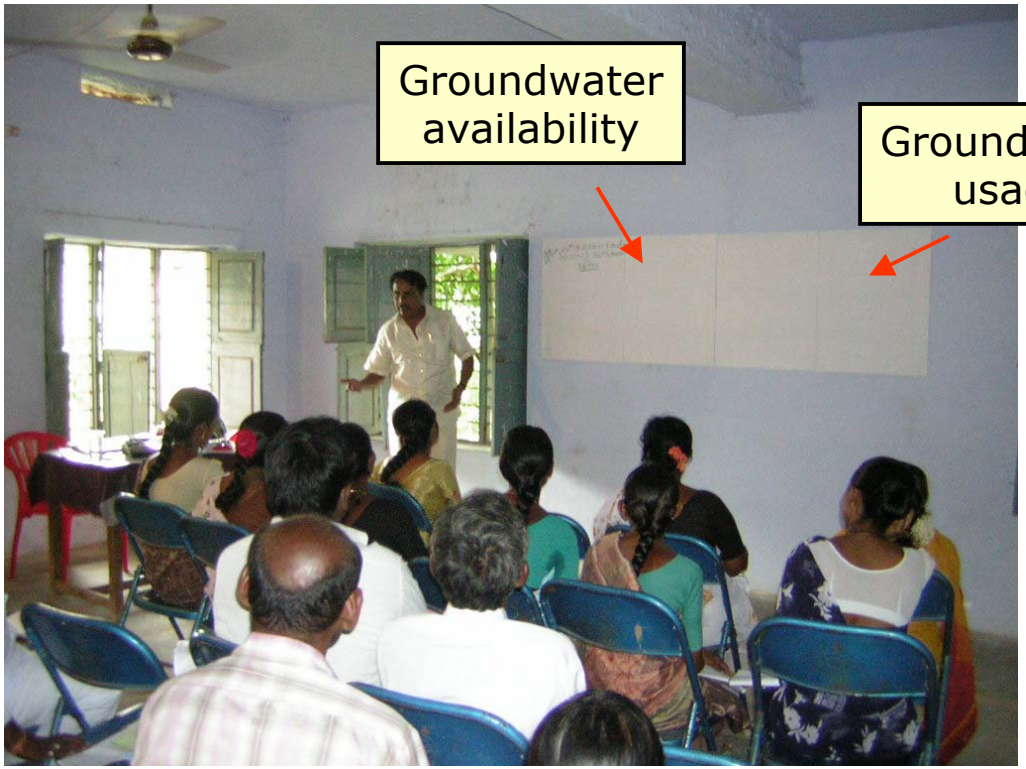
- Prepare village resource map using paper or coloured powder
- Indicate (in different colours)
  - Roads
  - Main building
  - Wells (plus condition)
  - Water harvesting structures
  - Local streams

Resource mapping

Participatory water budgeting

- Prepare a simple water balance for the area, calculating:
  - Rainfall and recharge co-efficient;
  - Water consumption:
    - Cropped area (main crops) times water consumption
    - Number of domestic users times use/capita
    - Number of animals times use/ capita

Participatory water budgeting



Preparation of micro-plans

- Compare results from trend analysis, water budget, transect walks and resource maps
- Identify actions:
  - Social regulation
  - Investment
  - Maintenance of water structures
- Micro-plan to be endorsed by local council

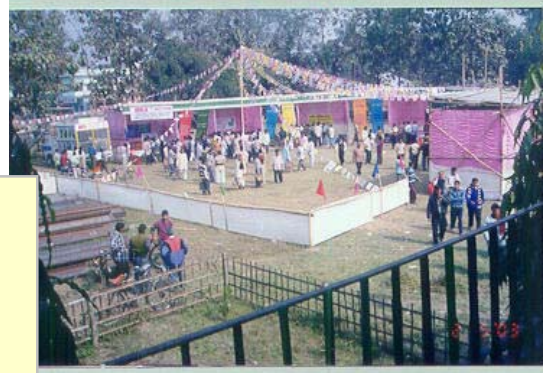
Preparation of action plans

Step 3: Create peer network

- Create peer effects – bring together representatives of several areas in subbasin in festival mode
- So that they start to:
  - Share experiences
  - Identify common issues
  - Experience mild competition (why are others doing better than we)

Step 3:
Create peer network

A local thematic **fair** is
a good way of bringing about
the **exchange of experience**
and **inspire** people to do
better or at least as good as
others in groundwater management



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Participatory Groundwater Management

6. Participatory Groundwater Monitoring

Why self-monitoring by groundwater users

To overcome lack of understanding of limitations to local groundwater resource

To come to common local agenda on groundwater management

Good example
Irrigation District 66, Mexico

Irrigation District 66, Mexico:

- Arid/ semi-arid environment
- Groundwater used for agriculture (90%), industry, and municipal use
- Farmers discover that they overdraft the groundwater
- A small group of farmers agrees on self-monitoring
- They install volumetric water meter on each pump and keep records
- This small group expands to full coverage

Participatory Hydrological Monitoring (PHM)

PHM refers to a set of activities carried out to keep track of the changes in a hydrological cycle by the users themselves with little input from outsiders

This module describes the steps in introducing Participatory Groundwater Monitoring

Objectives

- Discussion is triggered at the community level about rainfall - draft - water level relationship
- Water use plans are evolved by the community based on utilizable groundwater resources
- People-managed groundwater systems

Before getting started: identify Stakeholders in Groundwater Management

- Farmers (men and women)
- Drinking water users
- Other groundwater users
- Government departments
- Local government
- Watershed or water supply programs
- …

Steps in PHM process
-1- Preparation

- Reconnaissance/meeting with opinion leaders
- Awareness raising
- Delineation of watershed/aquifer system
- Water Resource Inventory

Awareness raising

Kalajatha, a rural folkart, is being used to draw large numbers and introduce the PHM activity

Delineation of hydrological units

- Desk Study
- Reconnaissance/Meeting
- Delineation on toposheet
- Field validation
- Final (manual) delineation
- Naming of Hydrological Units
- Listing of villages

Resource Inventory

- Collection of Secondary Data
  - Departments
  - Universities
  - Other Institutions
- Collection of Primary Data
  - Participatory Resource Mapping
  - Well Inventory
  - Inventory of surface water resources

Basic Documentation

- Hydrological situation
- Geology
- Geomorphology
- Rainfall pattern (historical data)
- Water bodies (drainage, tanks, wells, etc.)
- Status of groundwater development

MAKE SURE THIS BASIC INFORMATION IS AVAILABLE IN SIMPLE LOCAL LANGUAGE AND WIDELY SHARED AMONG STAKEHOLDERS

Steps in PHM process
-2- Setting up the monitoring

- Joint site identification: Rain gauge stations and observation wells
- Social feasibility study
- Procurement of equipment/material
- Establishing rain gauge stations and observation wells
- Supply of equipment to community

Site selection for:

- Rain Gauge Station
- Observation Well
  - Provision for water level measurement
  - Additional provision for discharge measurement
- Display Boards
  - Rainfall display board
  - Water level display board
  - Hydrological unit display board
  - Sign Board

Site selection:

Criteria for selection of site for rain gauge station

- **Open place** without any obstructions in the form of trees, walls, etc.
- The ground should be **flat** and **never** be located on the side or **top of a hill**
- In hilly areas, where level ground is difficult to find the rain gauge should be located where **wind could not cause eddies**.

Site selection:

Criteria for selection of site for rain gauge station

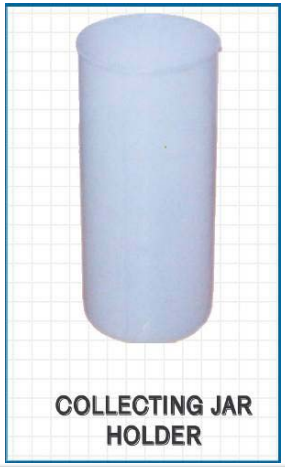
- **Distance** between the rain gauge and the nearest object should not be less than **twice the height** of the object. In no case the distance should be less than 30 meters
- The distance between the rain gauge and the fence should not be less than the **height** of the **fence**
- The land should be preferably provided **free of cost** and agreement should be made to that effect

Procurements

- Rain Gauge
- Insertion Pipe and accessories
- Water Level Indicator
- Calibrated Drum
- Stop-Watch
- Display Board material

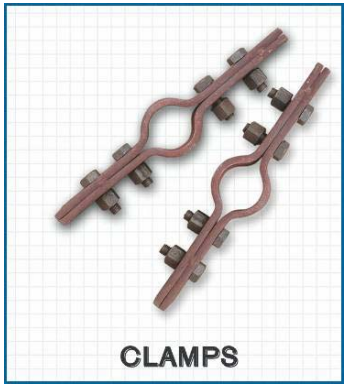
Procurements

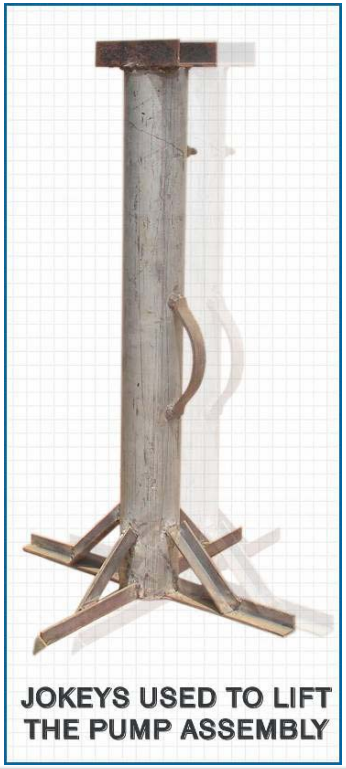
- Rain Gauge

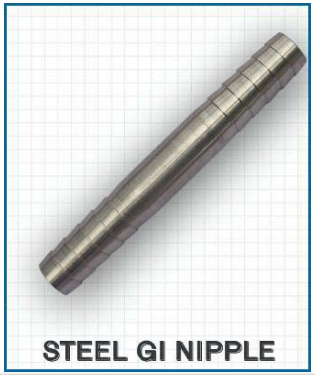


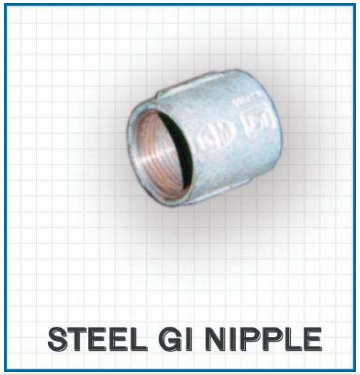
Procurements

- Insertion Pipe and accessories







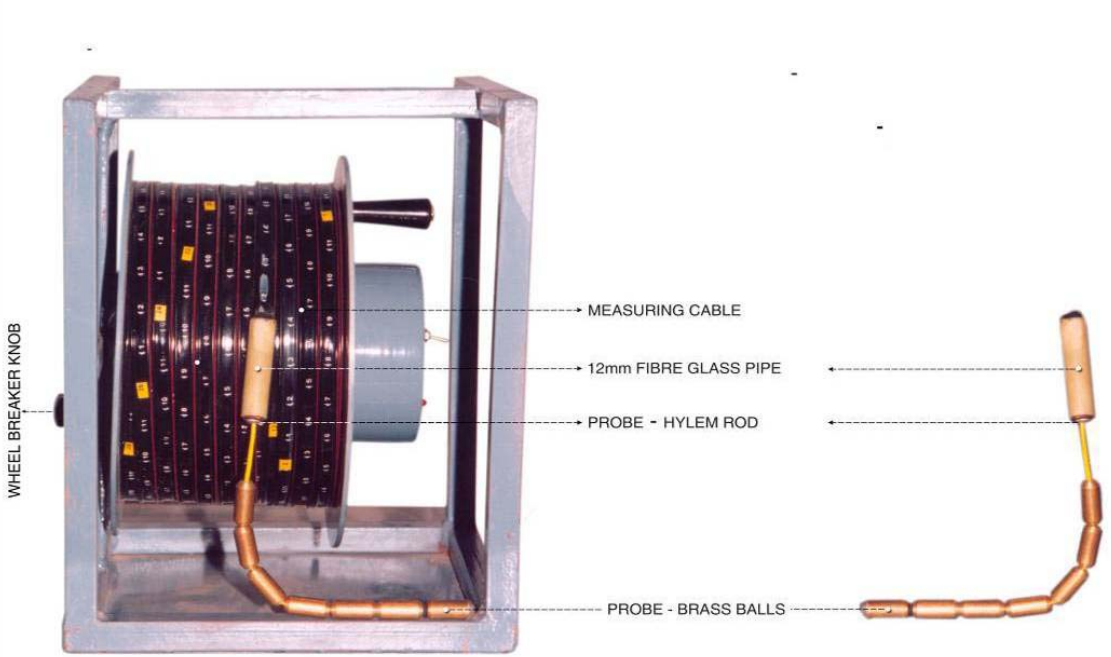


Procurements

- Water Level Indicator

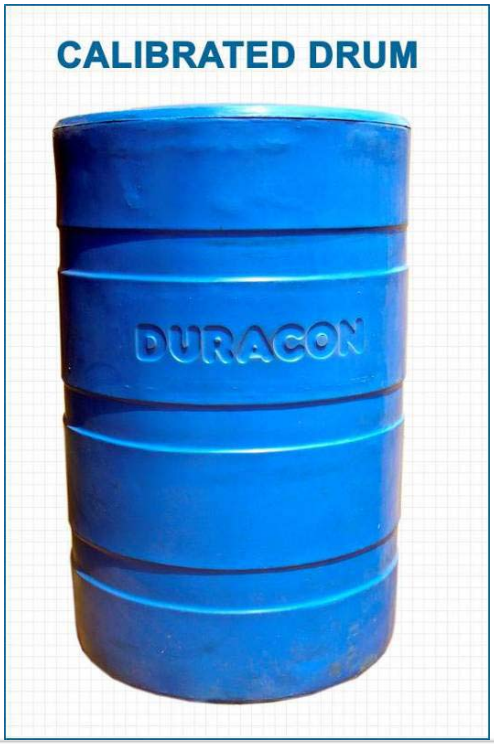
Procurements

- Water Level Indicator



Procurements

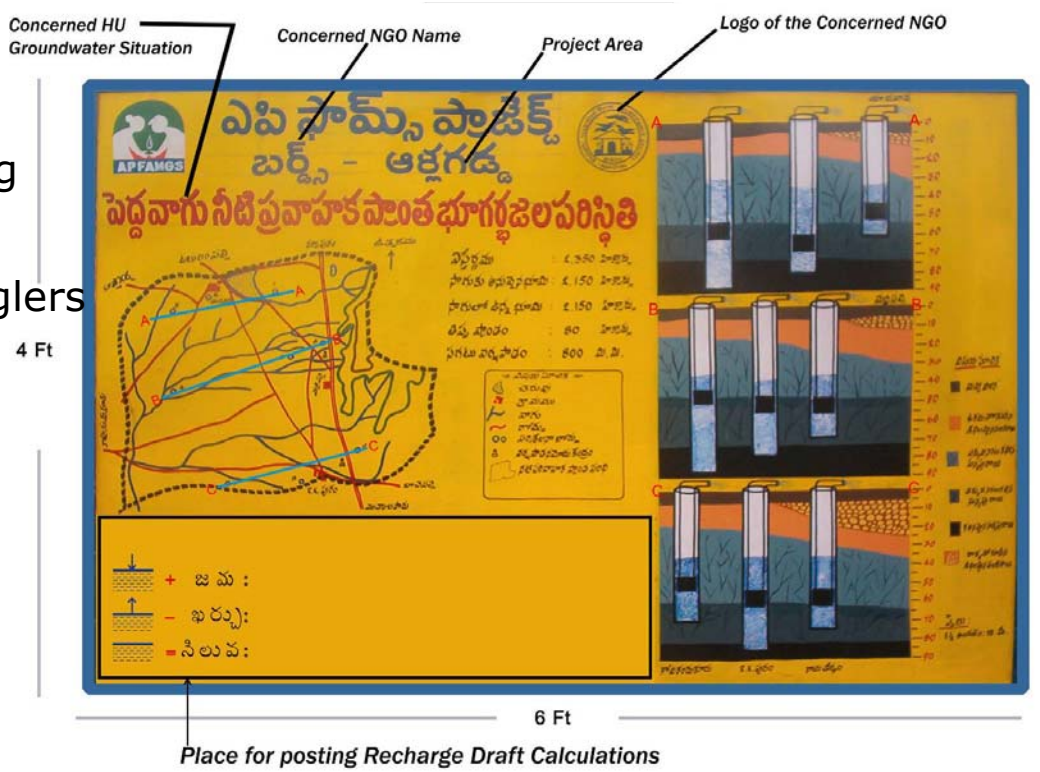
- Calibrated Drum
- Stop-Watch



Procurements

- Display Board material

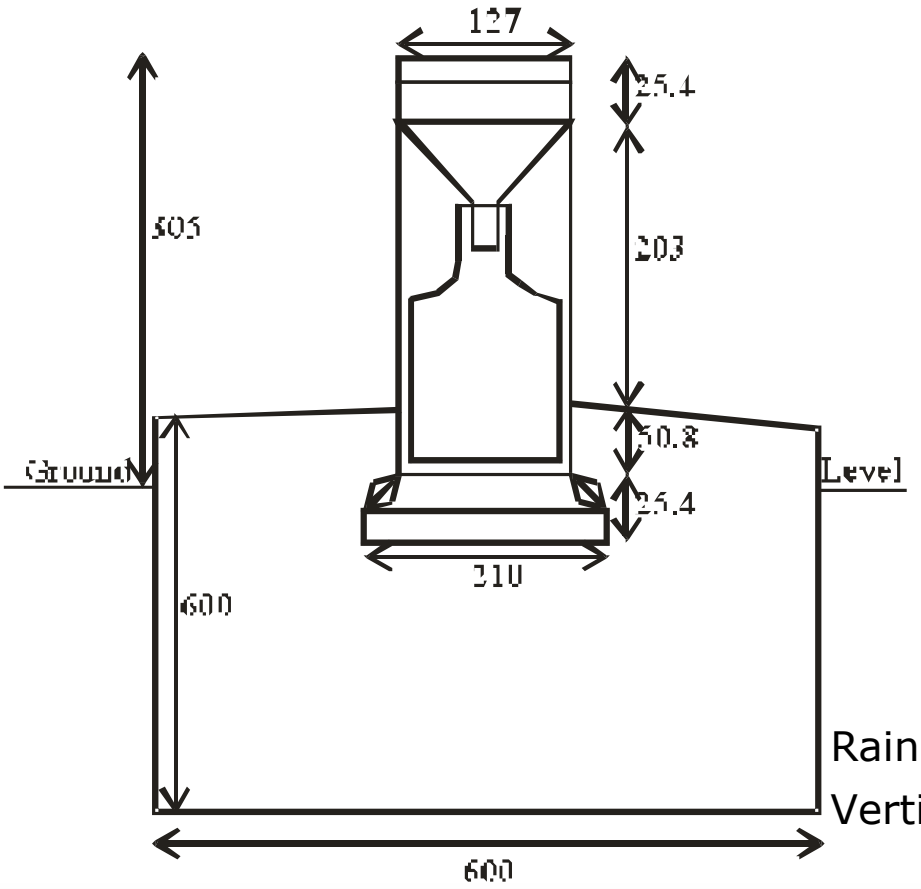
- Iron sheets
- Wooden planks
- Paints and painting material
- Iron poles and anglers



Establishing the monitoring unit

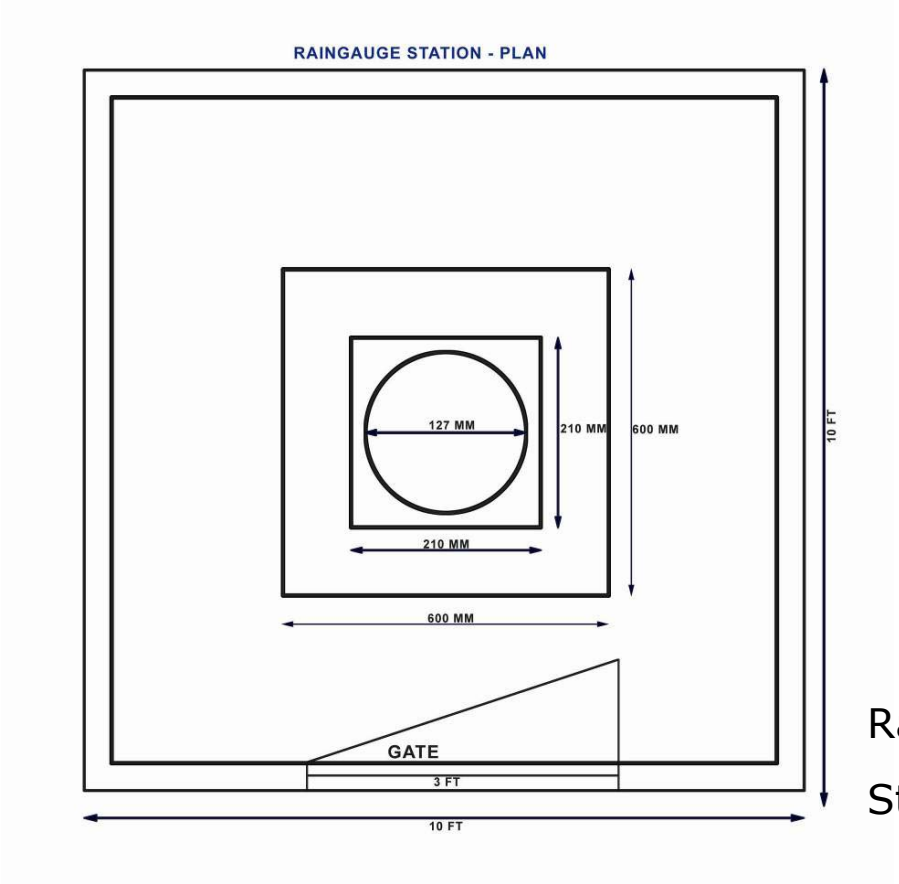
- Rain Gauge Station
  - Standard Plan
  - Fabrication of material
  - Installation
- Observation Well
  - Insertion Pipe
  - Provision for discharge measurement
- Display Board
  - Fabrication
  - Painting
  - Erection

Establishing the physical works



Rain Gauge Station:
Vertical Cross Section

Establishing the physical works



Rain Gauge Station:

Standard Plan

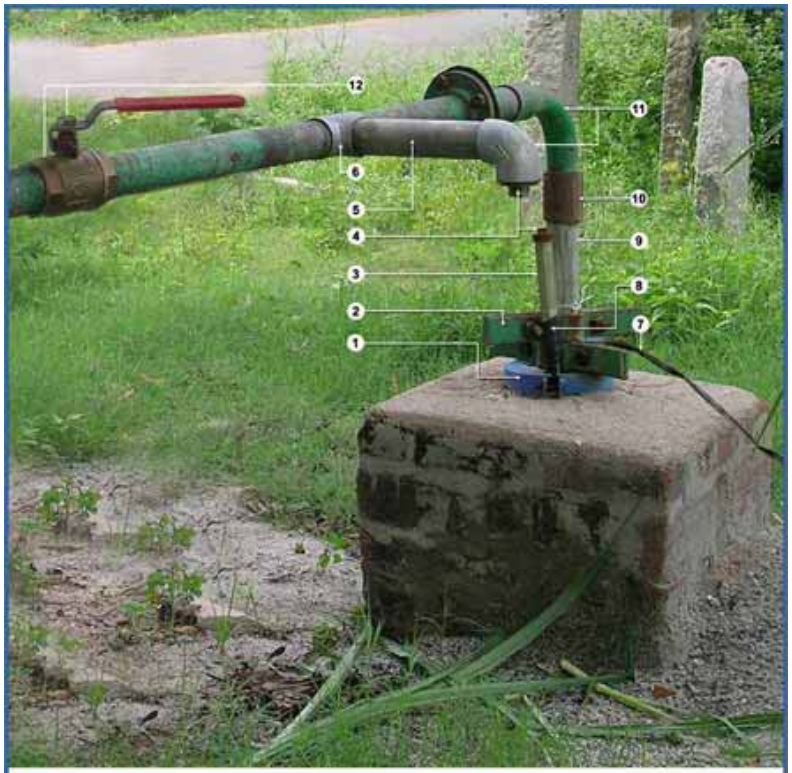
Establishing the physical works

Rain Gauge Stations

RAINGAUGE STATION - I

RAINGAUGE STATION - II

Observation Well



TYPICAL OBSERVATION BOREWELL AND ITS MODIFIED COMPONENTS

1. BORE CAP	5. CONNECTING GI NIPPLE	09. DELIVERY PIPE
2. CLAMPS	6. T - BEND	10. G I COUPLING
3. G I NIPPLE	7. POWER CABLE	11. L - BEND
4. END CAP	8. HDPE PIPE	12. GATE VALVE

Display Board

Display Board Rainfall Type

Display Board : Water Level Type

Board Width may vary depending on Number of OB Wells

Steps in PHM process
-3- Getting the monitoring going

- Farmer training in monitoring
- Farmer data management
- Erection of Display boards/data display

Farmer Capacity Building

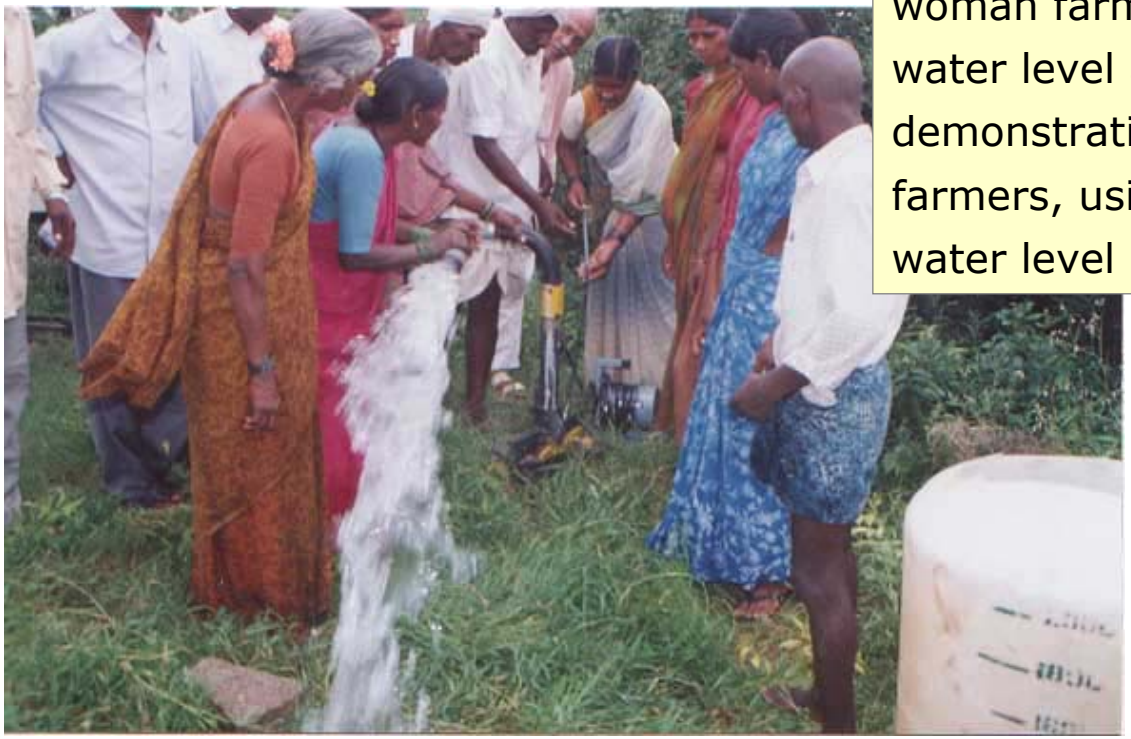
- One year Farmer data collection
- Crop Water Budgeting Spreadsheet
  - Groundwater Balance Estimation end of Kharif
  - Estimation of Crop-water requirement for Rabi
- Crop Water Budgeting Workshop
- Crop-Water Information Kiosk
- Operation, Maintenance and Repair

Farmer Capacity Building

Example:
Measuring Rainfall: Farmers measuring rainfall at the rain gauge station and demonstrating it to other farmers using Symon's rain gauge.

Farmer Capacity Building

Example:
Measuring water levels: A woman farmer measuring water level and demonstrating it to other farmers, using an electronic water level recorder



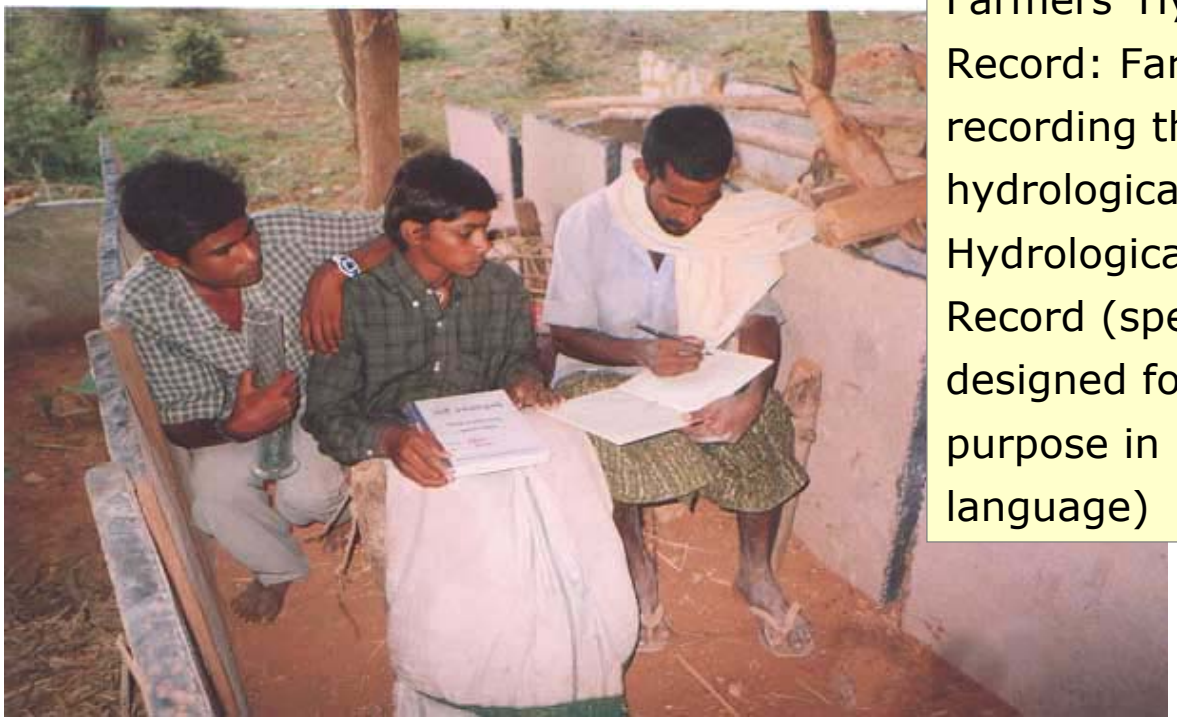
Crop Water Budgeting (CWB)

Observation well

Measuring borewell discharge: A farmer volunteer along with other observation well farmers measuring borewell discharge, using a calibrated drum and stop-watch

Crop Water Budgeting (CWB)

Hydrological Record



Farmers' Hydrological Record: Farmers at recording the hydrological data, in the Hydrological Monitoring Record (specifically designed for the purpose in local language)

Steps in PHM process
-4- Crop Water Budgeting

CROP WATER BUDGETING IS THE CENTRE PIECE OF PARTICIPATORY HYDROLOGICAL MONITORING AND CONCERNS THE PREPARATION OF A COMMON CROP PLAN IN LINE WITH EXPECTED GROUNDWATER AVAILABILITY

Crop Water Budgeting (CWB)

- Rabi (=dry season) Resource Inventory
- Groundwater Availability Estimation at the end of Kharif (=wet season), using information from resource inventory and participatory monitoring data
- Collection of Farmer Crop Plans
- Groundwater Balance Preparation for Rabi, using:
  - Expected demand on the basis of farmer crop plans
  - Expected availability from inventory and monitoring data

Crop Water Budgeting (CWB)

Activities

- Crop Water Budgeting Workshop – finalizing crop plans
- Support in agricultural extension (suggestion alternative less water demanding crops)
- Adoption Survey and Groundwater Balance Estimation, using results of Crop Adoption Survey

Crop Water Budgeting (CWB)

Participatory Water Budgeting (PWB)

Participatory Water Budgeting: A group of women farmers, discussing the crop-water relationship and planning for rabi season in a workshop.

Crop Water Budgeting (CWB)

Expected Outputs

- Base line resource inventory information updated
- Groundwater use in Kharif quantified
- Groundwater need for Rabi crops quantified
- Groundwater Balance for Rabi projected based on PHM data, resource inventory and crop plan

Crop Water Budgeting (CWB)

Objective

- Facilitate the adoption of low water consuming crops by the farmer

Results for Andhra Pradesh, India

⏩ This methodology is being used in Andhra Pradesh, India and has reduced rice cultivation to less than 7% and facilitated the introduction of new high water productivity crops

Presentation based on work of S Govardhan Das,

Andhra Pradesh Farmer Managed Groundwater Systems Project

and

contribution of

Steve Merrett (District 66)

Contributors

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Participatory Groundwater Management

7. Making Use of Water Laws

Regulating groundwater management by Law ..

Is best seen in conjunction with other initiatives –

- Planning
- Promoting local management
- Pricing

Two main categories of Groundwater Laws

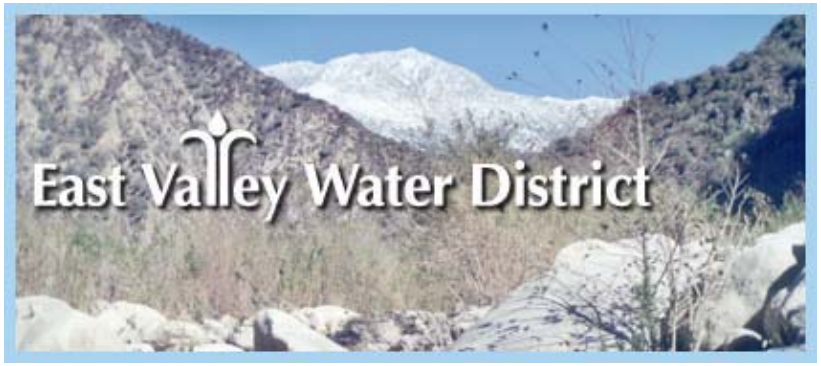
- Enabling laws
- Regulatory laws

Enabling laws

- Allow users to make rules and form own organizations
- If these comply with minimum requirements, than these rules and organizations are officially endorsed and enforced

Example 1: California, USA

- Groundwater users can establish their own associations and districts and make their own internal rules



Example 2: Balochistan, Pakistan

Groundwater Rights Administration Ordinance 1978

- Groundwater users in each basin can make rules
- Rules will then become official
- New wells will be approved through procedures of committees

Regulatory laws

Central Authority by Law determines, ao:

- Well permits
- Drillers licenses
- Rules on well spacing
- Zoning rules
- Pumping concessions

An example of a very old regulatory law..

Harim (Muslim Law):

- Minimum distance between two wells, springs or qanats depending on terrain conditions

Example: Andhra Pradesh Water Land and Trees Act, India

- Elaborate procedures for permission to develop new wells
- Elaborate procedures for registration of drilling rig operators

Regulatory laws, when taking serious, can create resistance..

Strike of drilling rigs after announcement of Water Law in AP, India

Drilling rigs had to be officially registered:
Operators feared interference and unfair practice

Many Laws mix enabling and regulatory elements: Example: Water Lay Yemen

- Law determines a.o.
  - Zones
  - Permission for well depth (beyond 60 meter)
- Law creates possibilities for Water Basin Committees and Water Zone Committees

Most Water Laws however are

NOT EFFECTIVE!

What makes a Water Law effective

- The Law is a fair and reasonable way to resolve the main water issue in the area
- There are organizations behind it that can (and does) implement the Law
- The Law is widely known and accepted

This requires:

- **Regulatory Impact Assessment**
- **Regulatory Capacity Assessment**
- **Legal Awareness**

Regulatory Impact Assessment

A short structured assessment of:

- The issue giving rise to the regulations
- The various options to address the issue
- The various impacts of the options
- Recommended option
- Compliance costs for different groups of stakeholders
- Arrangements for enforcement

RIA – example of contents

Issue and objective	Competition assessment
Associated risk assessment	Impact on small business
Identifying options	Consultation and discussion
Identifying, valueing and quantifying benefits of options	Enforcement mechanisms
Issues of equity and fairness	Monitoring mechanisms
Compliance costs for different stakeholders	Recommendations and approval

Regulatory Capacity Assessment

Step 1: Analysis of the law (purpose, structure, content)

Step 2: Assessing the most urgent outputs of the law

Step 3: Determination of clauses that require capacity building (assess which outputs and activities need to be delivered by different organizations)

Step 4: Translate outputs and activities in capacity building areas

Step 5: Determination of capacity building priorities in light of most important outputs of the law

Legal awareness

- Legal awareness is a 'must', because otherwise the Law is:
  - Not known to those directly involved
  - Not even known to the legal profession
- Will 'level' the playing field

Essentials of a good groundwater law

- It is implemented
- It relates to other processes, for instance:
  - Surface water management
  - Physical planning
  - Pollution control
- There is a process of monitoring linked to it

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Participatory Groundwater Management

8. Awareness Building in Water Management

Why is awareness raising an important component in promoting water management?

As such awareness raising is important in:

- Supporting participatory processes
  - ⏩ it helps active and informed involvement and 'levels the information playing field'

- Developing self-regulating water institutions
  - ⏩ can be an important drive for communities to establish and improve local institutions for the management of water resources

Important:

Optimal combination between different communication channels is required:

finding a balance between reach, involvement, content and influence

Characterization of campaigns

Four Criteria:

- **Reach**: how many persons does the campaign reach?
- **Complexity** of the content: how much 'information' is supplied to the public?
- **Involvement**: extent to which the public is personally involved in activities
- **Influence**: amount of influence the target audience has on the campaign content

Characterization of campaigns

Three basic modes of campaigning based on these four criteria (Reach, Complexity, Involvement, Influence):

- Market mode
- Educational mode
- Social/local mode

Models for campaigning

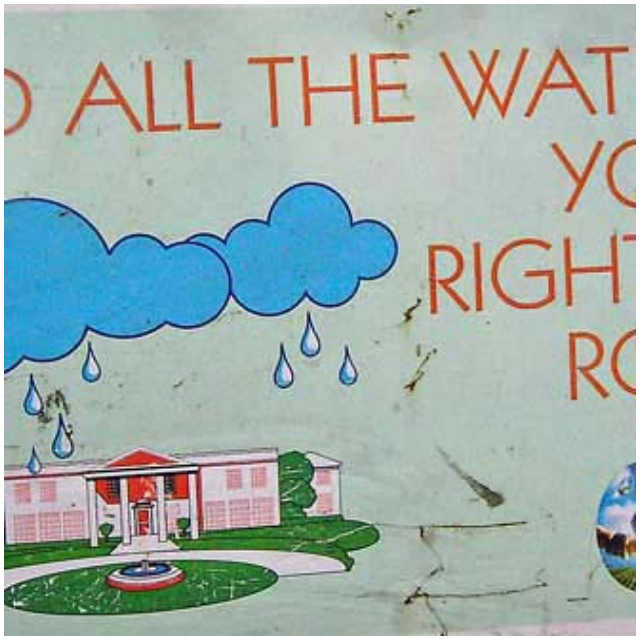
Market mode:

- large-reach
- simple content
- low level of active public investment
- low level of audience influence

Example: waste disposal bins with sign mentioning that throwing waste away does not take any effort (Netherlands; bins with sign are widespread over the country)

Models for campaigning

Educational mode:



- medium-reach
- relatively complex content
- high level of public activity
- low to medium level of audience influence on the content

Models for campaigning

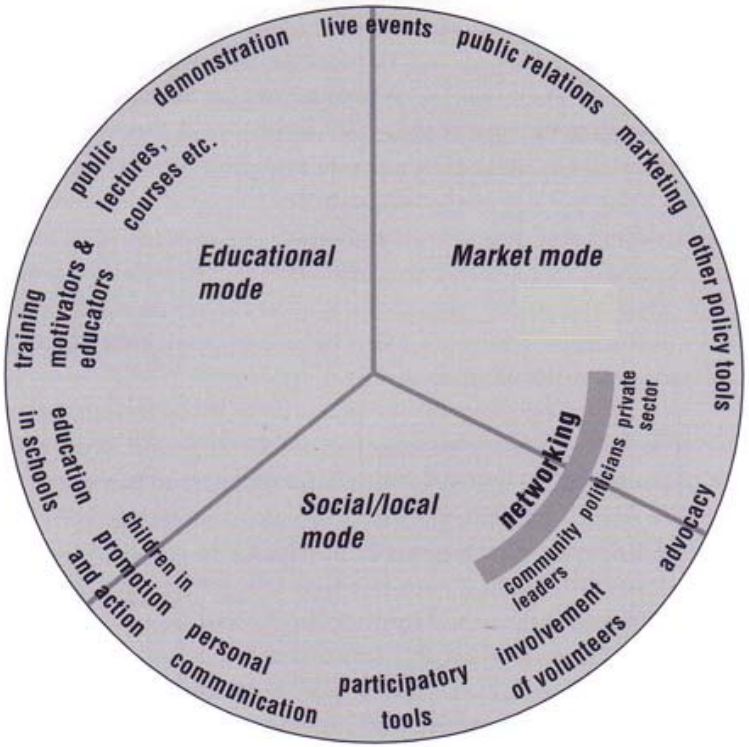
Social/local mode:

- low-reach
- medium level of content
- high level of active public involvement
- high level of audience influence on the content

Models for campaigning

- A good campaign is an optimal **combination of elements** from the different modes

Models for campaigning



Each mode has its advantages and opportunities that can be a unique contribution to the total mix of campaign strategies

Combining models for campaigning

An example:
The starting point was an **educational** programme in a school.

Combining this with an approach from the **market** mode by sending press releases to the media resulted in more public attention for the theme

Advocacy next helped to get the programme on the regular school curricula.

Planning awareness campaigns

A good strategy depends on sound knowledge of physical, social and cultural circumstances of the target group(s)

Planning awareness campaigns

Design of an awareness programme may consist of the following steps:

- Pre-programme research
- Message positioning
- Design and pre-testing
- Preparing integrated programme

Pre-programme research

A. Identify unwanted practices
B. Select practices for intervention
C. Select target audience

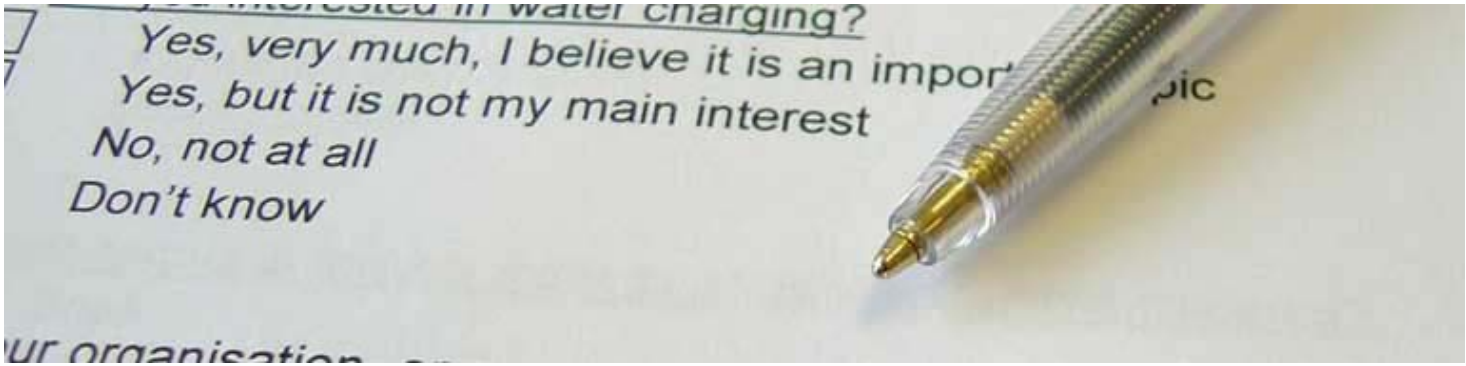
through:

- (un-)Structured observations
- Literature search
- Interviews / focus group discussions
- Composing a problem tree

Pre-programme research

Example Investigating knowledge level

Gaia, an environmental NGO in Georgia investigated the environmental knowledge of teachers. A specially designed questionnaire, covering 40 schools, revealed lack of knowledge and poor training, especially in environmental issues.



Message positioning

- Do target groups perceive a link between unwanted practices and the problem?
- What motivates those who employ "good" practices?

through:

- ✓ Focus group discussions
- ✓ In-depth interviews with current users of good practices
- ✓ Trials

Message positioning

Example Use behaviour trials

WaterAid's Water, Sanitation and Hygiene Program (Tanzania) advocates the use of behaviour trials with volunteers to investigate the acceptability of new practices. Volunteers are asked to try the behavioural changes suggested in the campaign (e.g. using a new type of toilet). The volunteers are then asked to review the changes, whether they are feasible in the long term or need some adaptations. Volunteers might also have some suggestions how these changes can be promoted successfully.

Design and pre-testing

A. Select communication channels

B. Design and pre-testing of material

Design and pre-testing

A. Select communication channels

B. Design and pre-testing of material

- What channels are currently used for communication?
- What channels are trusted for such messages?
- What types of material and events are likely to be attractive, understood, believed and remembered?

Preparing an integrated programme

- What is the likely reach and cost of each channel?
- What combination of channels is most cost effective?

through:

- Consultation with community groups and collaborating agencies
- Cost estimates
- Piloting

Some examples

Examples

Thames Water (UK) has focused part of their campaign on children, with a special website and a contest with water-wise T-shirts as rewards

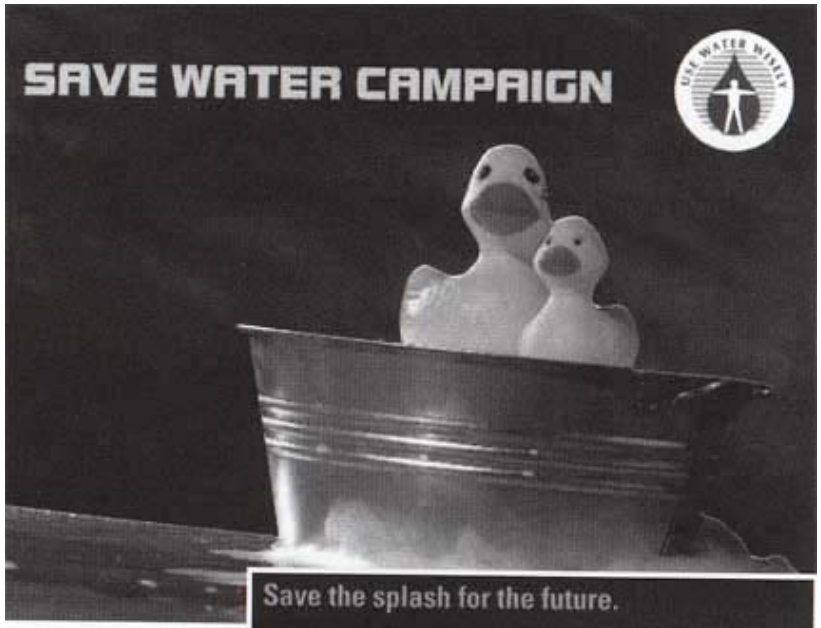
Examples

Young people as promoters and activists:

Involving children in finding and reporting water leaks

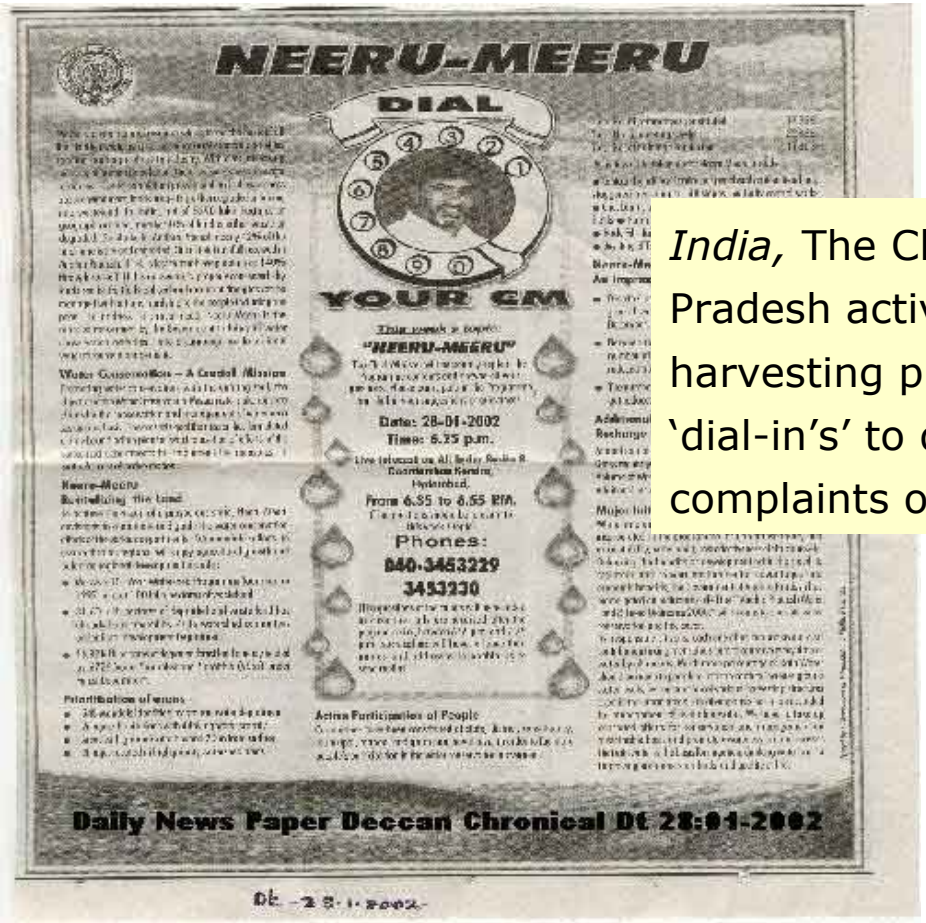
Examples

Public Utilities Board (Singapore) provides free tickets to public transport with a promotional message on one side.

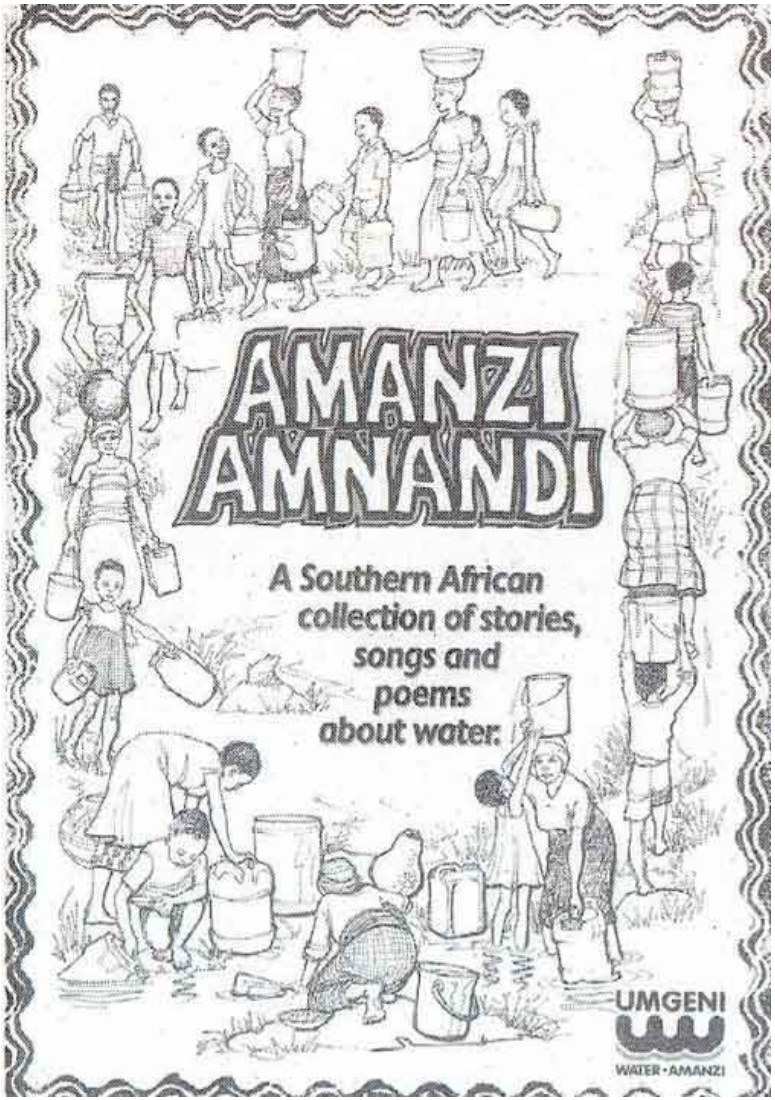


The ticket (bottom picture) is wrapped in a small envelope (top picture).

Examples



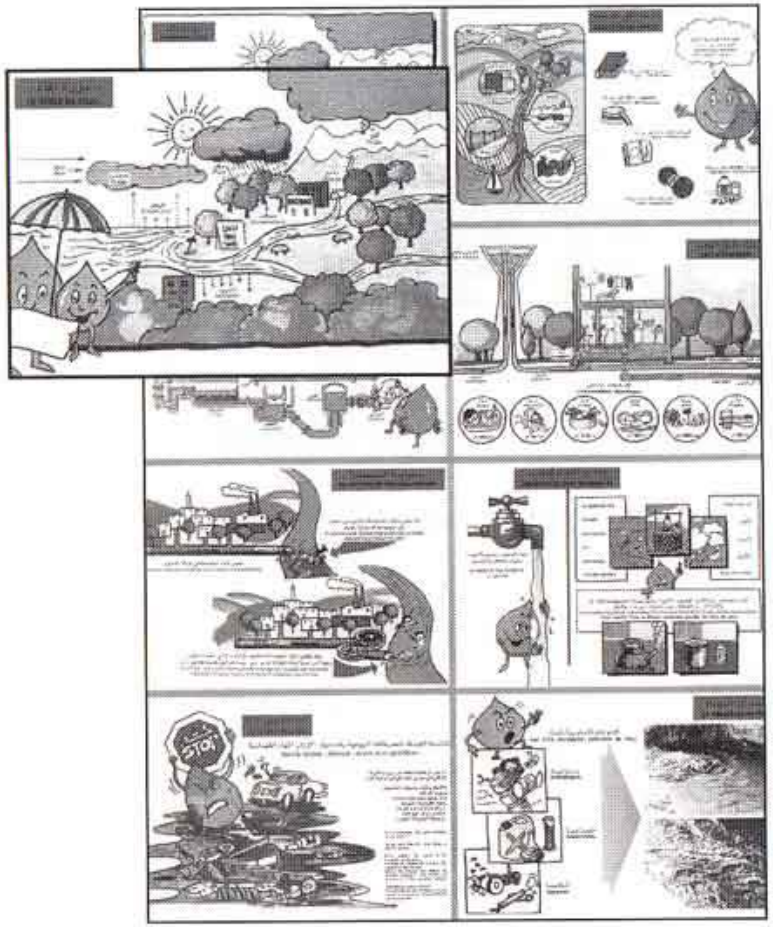
India, The Chief Minister of Andhra Pradesh actively promoted water harvesting program and organized 'dial-in's' to discuss experiences and complaints on the program.



Examples

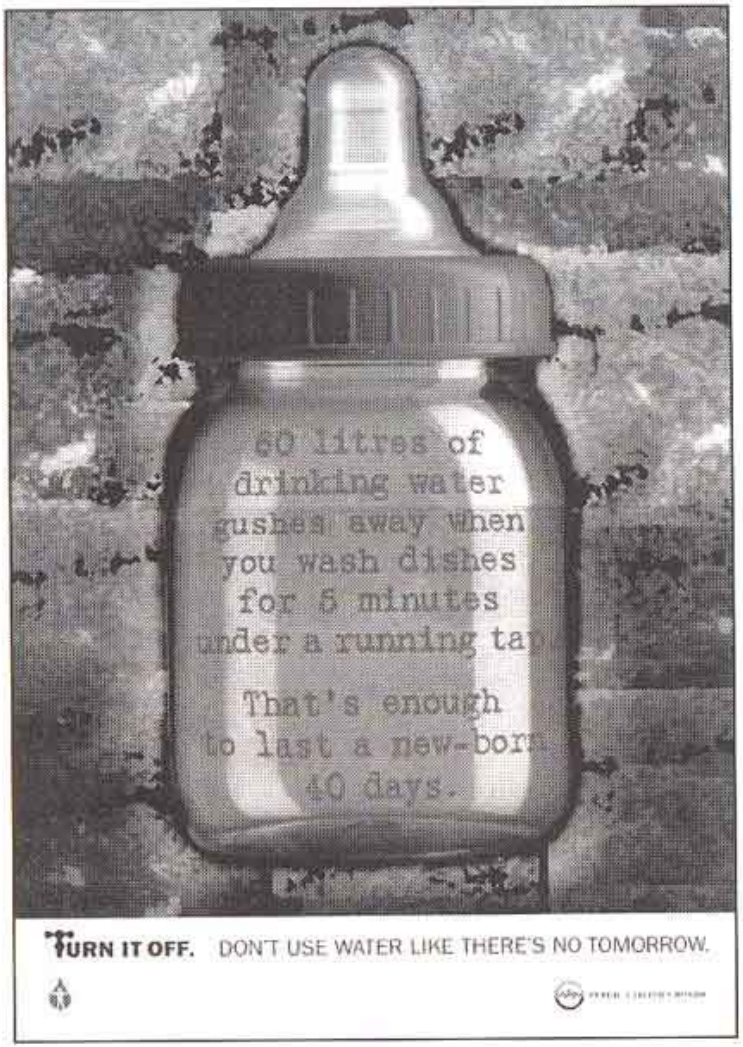
Umgeni water (South Africa) has produced a booklet with a collection of southern African songs, stories and poems. The book also contains some creative ideas for children to use handicrafts related to water.

Examples



Educational posters:

- Often have a lot of information and interesting details
- Meant to have a closer look



Examples

Promotional posters:

- Clear at a glance
- Usually one large slogan and few details

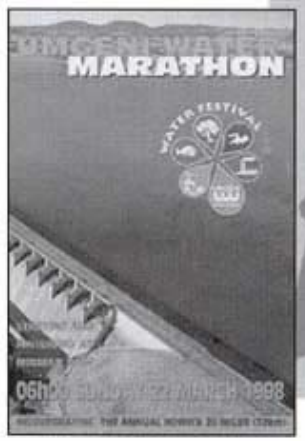
Examples

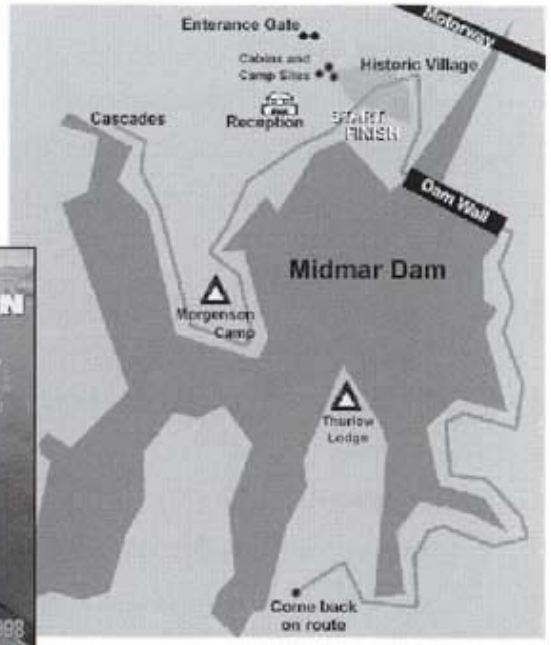
Festivals & exhibits

The *Clean Water Celebration (Rivers Project, USA)* is an annual event honoring the rivers of Illinois. Participants attend workshops, make presentations on local rivers and water projects, network with other river stewards, learn about current water issues etc. Other activities include demonstrations, exhibits, school booths, hands-on science activities, theatre, arts and music.

Examples

Umgeni Water (South Africa) organizes a marathon as part of their water festival. The starting point is a dam and the marathon is run around a scenic lake





Suggestion:

- Giving publicity (through media) to the awareness campaign itself can have a powerful 'ripple effect':
  - More attention
  - More enthusiasm

Suggestion:

- Try using existing channels of communication to enhance appeal and become the talk of the town:
  - Political leaders
  - Religious messages
  - Celebrities

Important:

Awareness raising may be misunderstood as implying that one party is going to teach another party, so that this other party becomes 'aware'.

Important:

Awareness raising should be seen as an interactive movement in which as many stakeholders as possible are involved!

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