12.2 Second Presentation of Session II

Dr. S.A. Prathapar, Theme Leader - Productive Water Use, IWMI, on Technical Challenges and Solutions for Sustainable Groundwater Management – An International Perspective.

Good afternoon. Thank you for giving me an opportunity to speak about groundwater, which is my specialization. Previous presenters spoke about groundwater governance, and I heard about issues faced in groundwater in Sri Lanka and also about programs currently under way. The solution to a problem is awareness. Problem is already here. We are halfway through. I was paying a lot of attention to the speech of the Chairman of WRB, Mr. Premarathne. He identified a broader framework, where the issues are coming up and what they are trying to do; starting from measuring to monitoring, modeling, and forecasting. They continue to manage groundwater not only on the institutional side of it but also on the technical side of it. I will talk about challenges raised by various speakers and see what people have done outside.

Technical challenges?

- Where is groundwater?
- How much is there?
- Is it enough?
- How do we share it equitably?
- How do we use aquifers to hedge against variability? That in the context of climate change.
- Problems other than groundwater depletion! (water quality and other challenges)

From time to time you have to check whether the stethoscope is working right and also add piezometers where changes in groundwater level are more than desirable for which you need an additional budget.

Talking and worrying about the quality were going down. And there are other challenges also. I will talk about a few of those things.

Where is Groundwater?

Rationalization of groundwater monitoring network

To find where the groundwater is we need to have a network of piezometers. In the morning we heard a monitoring network has been planned with 103 piezometers. These are like stethoscopes measuring the health of groundwater. So, if we want to monitor groundwater we need to have a network rightly designed, rightly placed and righty monitored. Groundwater monitoring is a very expensive business. Another piece of information we heard was that 9,700 wells are monitored with 1,300 monitoring points. How do we know that we are monitoring the right way, at right locations and at the right frequency? These have to be answered. So one of the studies I was involved with were similar but done in a much smaller scale in Oman where 200 different wells were monitored. The water levels were monitored daily and the water quality, once a year. These are not transmitted automatically. Somebody has to drive these distances, bring data to the laboratory, enter the results, and process and analyze them. These constitute very expensive work. Also from time to time you have to check whether the stethoscope is working right.

There are new techniques that eliminate unnecessary piezometers. You can have the desired number of piezometers using this method. You are not only looking at water levels going up or down and whether water quality is good or bad but whether you are using the right kind of piezometer network. This was first used in gold mining industry and is now widely used in the groundwater sector. If you want to perceive this kind of analyses sometimes IWMI would be able to provide assistance.

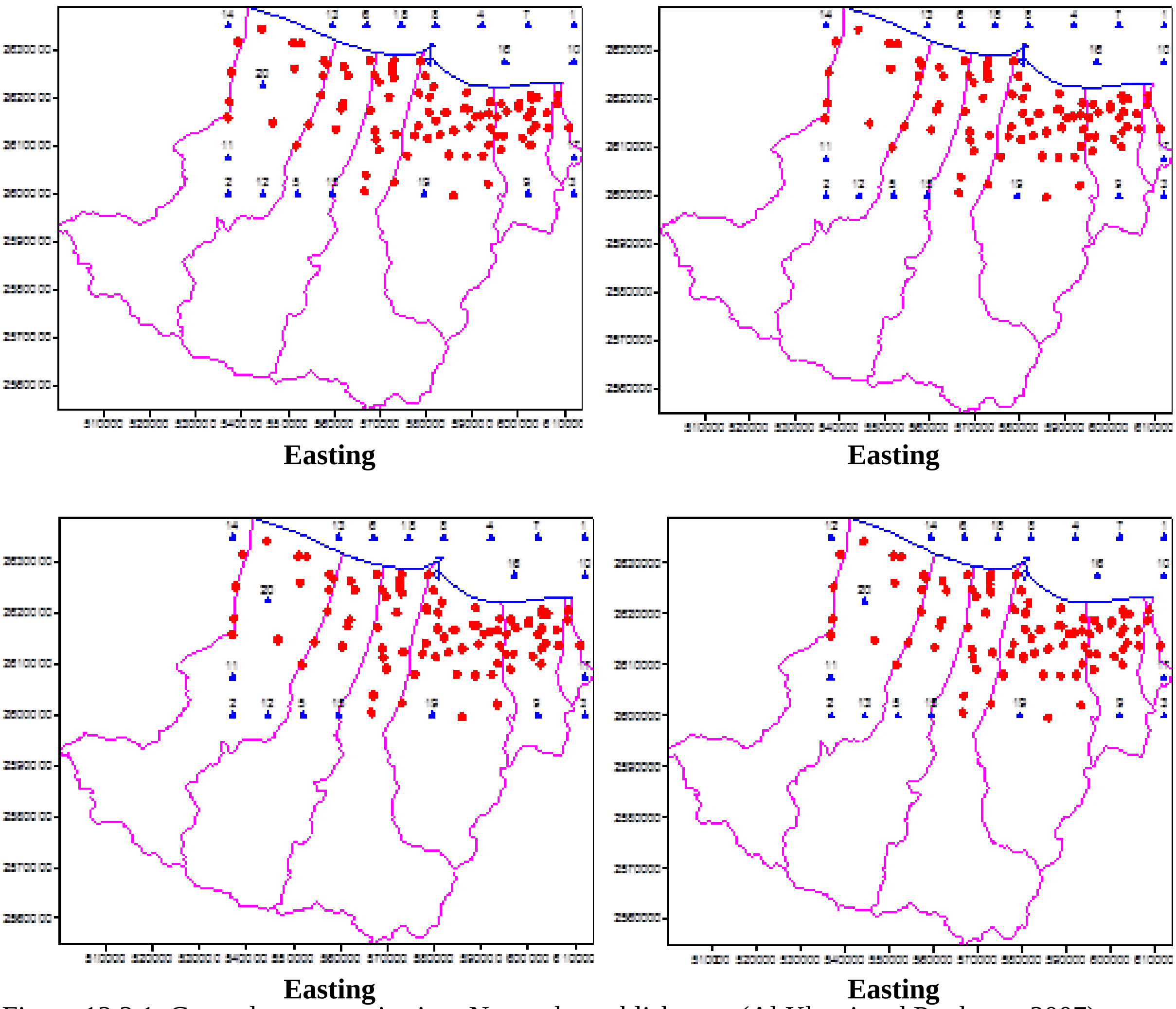


Figure 12.2.1. Groundwater monitoring: Network establishment (Al Khatri and Prathapar 2007).

Locations where bores need to be eliminated.

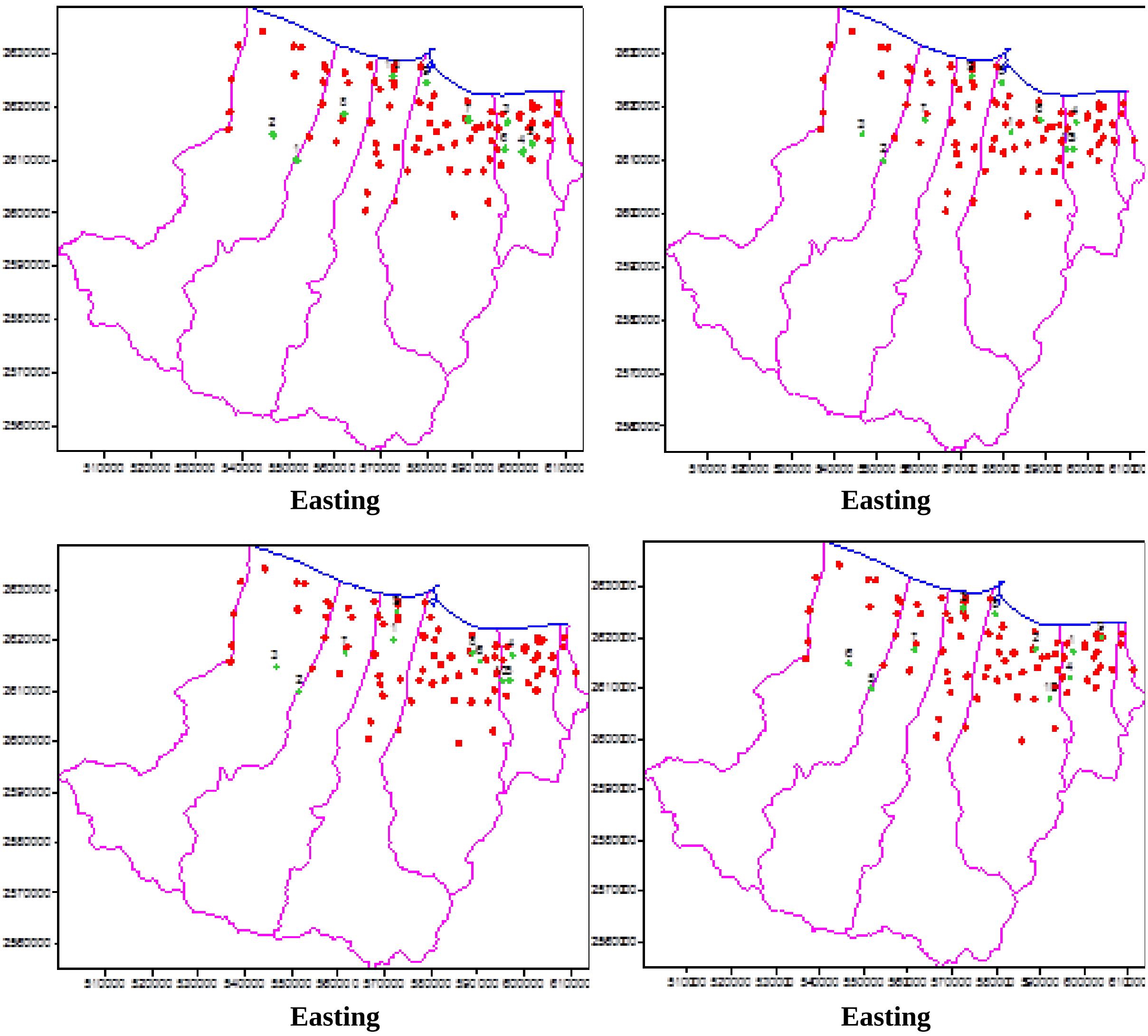


Figure 12.2.2. Groundwater monitoring: Network establishment (Al Khatri and Prathapar 2007).

Locations where bores need to be eliminated.

How much is there?

Estimating sustainable yields and groundwater assessment.

How much can I pump, where, for what, for how long, and so forth? There are techniques available; starting from simple tilt pot type based on piezometer data monitored over a year or going into some detailed levels of modeling to decide where the recharge is taking place, and how it is moving through the aquifer system. The mountainous area may be getting recharged and the recharge gradually moving to its dry zone part. There are techniques to do these. This particular study was done for the groundwater basin called Murrumbidgee Leaky Aquifer in Australia. It is very complicated and has multi-layers of hydrogeological formations. Certain aquifers are pumpable and others are not. For the leaky aquifer we developed a three-dimensional model. We calibrated it and started doing some numerical simulations. At one particular point there is a crossover and allocations are done based on that. This number is used to decide the land entitlement. It is part of the groundwater plan.

Table 12.2.1. Groundwater assessment: Estimating safe yields (Prathapar et al. 2002):

Estimating sustainable yields

Lower Murrumbidgee Leaky Aquifer

Three stratified aquifers.

MODFLOW model calibrated.

Numerical simulations to determine aquifer response to pumping.

Safe yield is when pumping equals leakage.

Methodology applied to others.

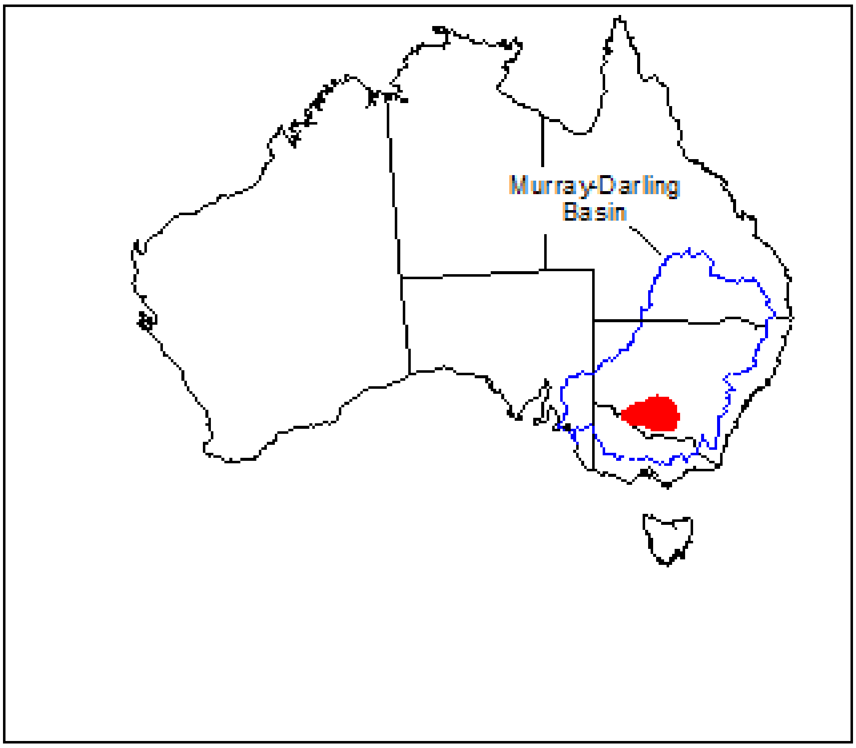


Figure 12.2.3. Lower Murrumbidgee Leaky Aquifer (Marked in red)

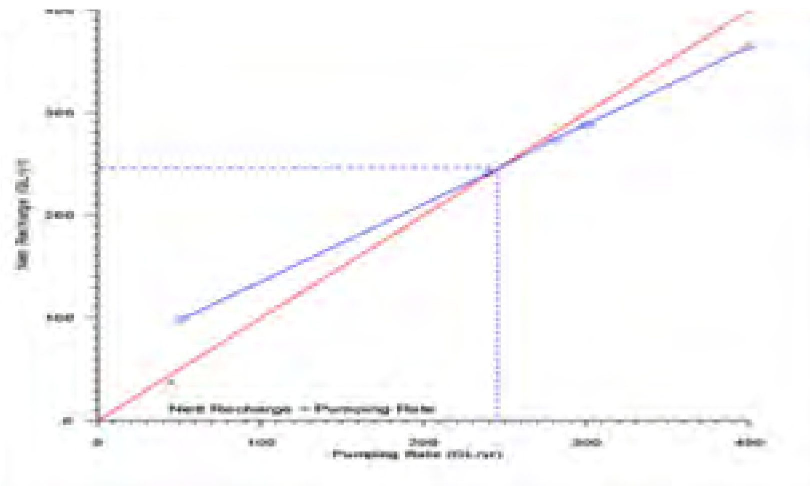


Figure 12.2.4. Safe yield is when pumping equals leakage.

Is it enough?

Land and water use optimization - Matching land use – Swagman options – Prathapar et al. 1997.

This is matching lands to water availability. If the evaporated demand created by a crop matches with the available water, that is an optimum situation. The problems come in the areas where the land use and the water availability and the water use patterns are not optimized or matched. In Punjab and also in Gujarat the groundwater levels are going down. Their land use is more than water availability; their goals are larger like food security, income generation, etc. This is not sustainability.

Example of sustainability in Australia -

It was planned for 500,000 ha of land

- Simultaneous profitability and sustainability.
- Hierarchical dual criteria optimisation model.
    - Maximize profits – gross margins.
    - Minimise recharge.
- Physical constraints.
    - Land and water availability.
    - Land suitability.
    - Hydrogeology.
    - Recharge.
    - Salinization.
- Non-physical constraints.
    - Farmer preferences.
    - Permanent plantings.

Figure 12.2.5. Sustainability in Australia.

Photo credit: S. A. Prathapar Shanmugam.

How do we share it equitably?

Groundwater sharing and allocation

Water interference is a serious issue in managing a limited resource, e.g., different organizations install groundwater pumps independently. Now I am talking about interactions and interferences with each other. WRB has developed a simple tool which they can show the farmers when new requests come for drilling wells. WRB can explain how these interfere/interact with nearby wells as in the picture below (Figure 12.2.6 Groundwater allocation - Prathapar and Piscopo 2002 - Well interference and drawdown evaluation).

Managed aquifer recharge (MAR)

How do we use aquifers to hedge against variability?

As the graph below shows no rains come for 7 months and then it rains cats and dogs. Will it recharge? If there is storage capacity we store it. Otherwise it is stored in the ground; that is recharge.

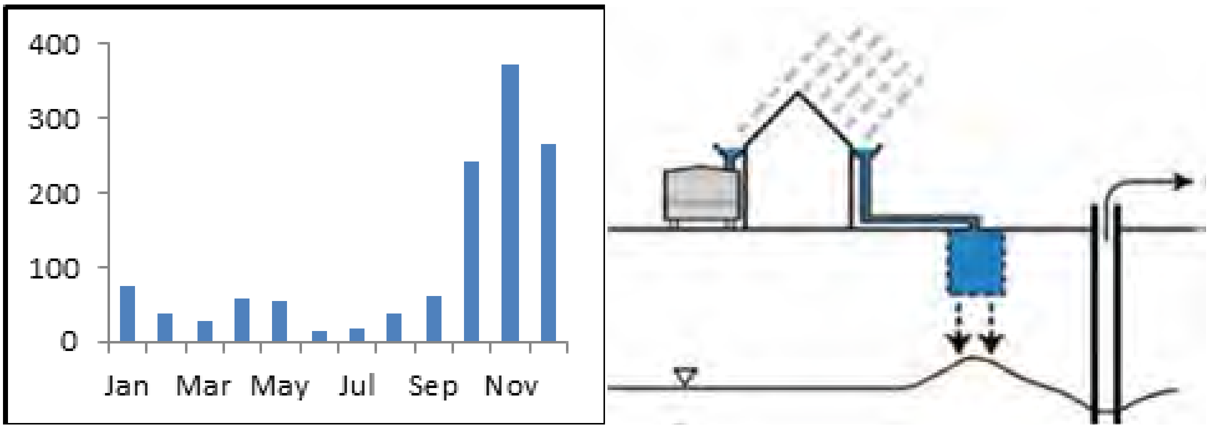


Figure 12.2.6. Rooftop rainwater harvesting and managed aquifer recharge (MAR).

In rainwater harvesting rainwater goes to a recharge pit from gutters and is then released to the ground for recharging. In the eastern and the northern parts of Sri Lanka we have a karstic sand aquifer which is permeable. If you pump out this recharge from your garden the water level of the garden belonging to the next house goes down. This is called a social aquifer. Imagine every house has a recharging pond. It would be a very good system. WRB could design a program for collecting rainwater from all existing houses with some financial assistance from banks. In India, programs of this type are implemented on government subsidized systems. IWMI too may help.

In coastal regions, aquifers are very shallow so people have to wait a long time to get water from wells. If rainwater from each house is collected into an individual tank it will benefit the people a lot.

Other groundwater-related challenges

Contribution of shallow water table to evaporation and transpiration of winter wheat in silt loam soils in the Ferghana Valley.

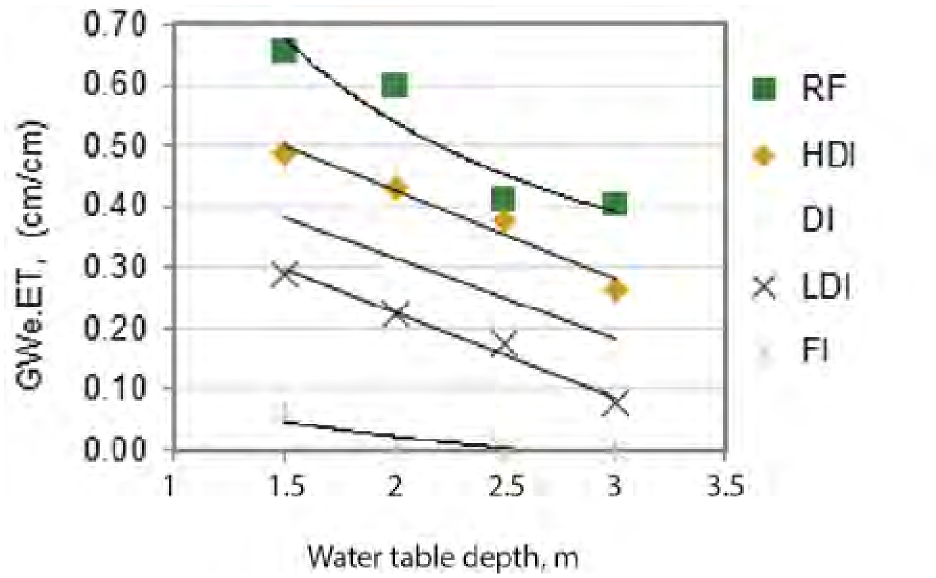


Figure 12.2.7. Contribution to evaporation and transpiration in silt loam soils in the Ferghana Valley.

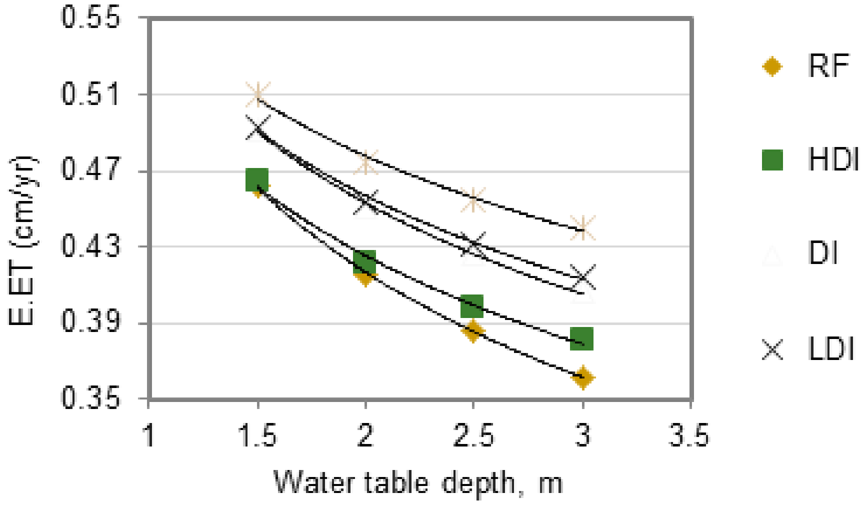
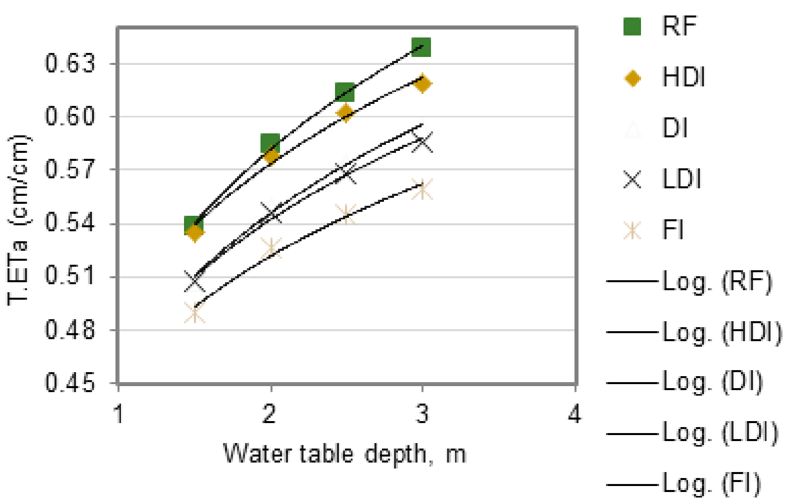


Figure 12.2.8. Contribution to evaporation and transpiration in silt loam soils in the Ferghana Valley.



Modeling scenarios:

RF – Rain-fed winter wheat

HDI – High deficit irrigation

LDI – Low deficit irrigation

Figure 12.2.9. Contribution to evaporation and transpiration in silt loam soils in the Ferghana Valley.

We talk widely about the groundwater level going down but if it comes up there will be waterlogging which will creates problems. We did some studies in Central Asia to find how irrigation water is managed there. It maximizes water use by pumping out water from the water table when roots get near it. In areas like System H in the North Central Province, Sri Lanka, the groundwater level is very shallow. We have to rethink about how we should manage these areas.

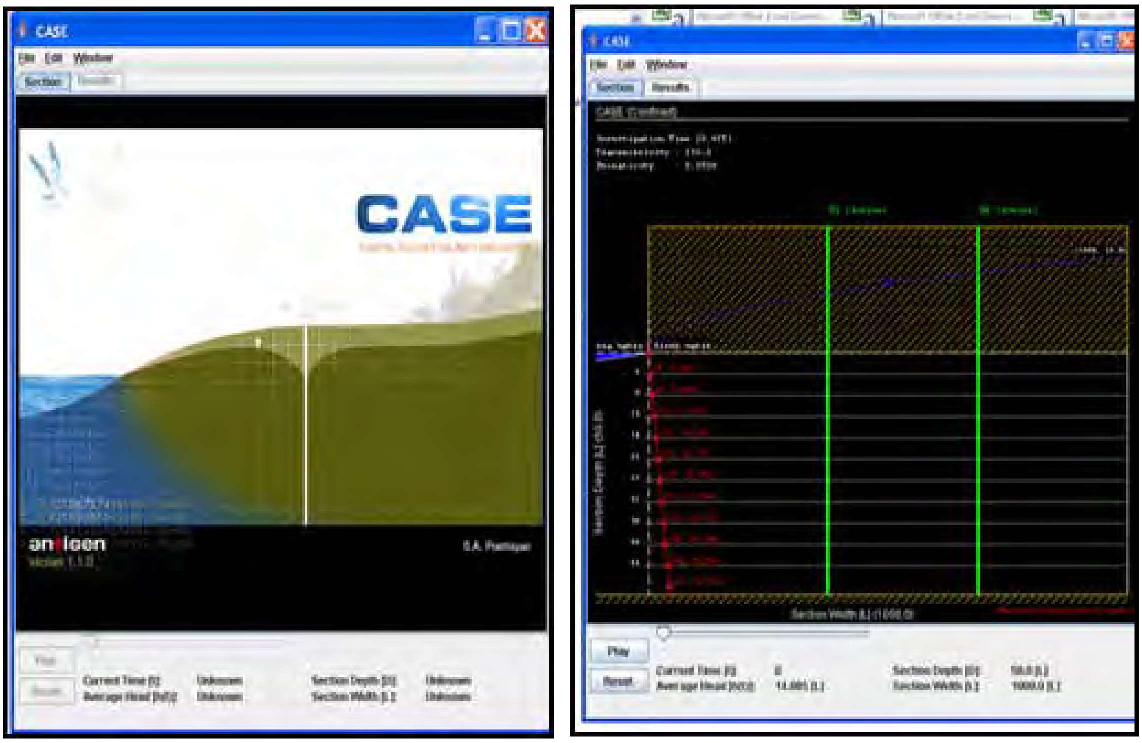


Figure 12.2.10. Groundwater protection - Coastal aquifer salinity evaluation: Prathapar (2002).

Groundwater protection: Seawater intrusion, non-point pollution, Upcoming of inland aquifers –

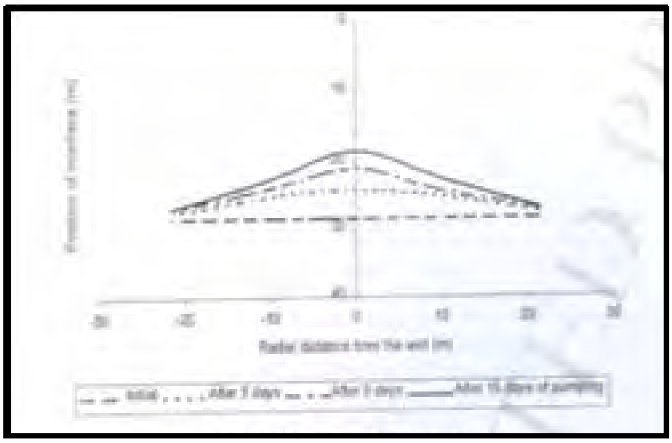


Figure 12.2.11. Interface movement during pumping

- Common problem in South Asia
- MODFLOW MT3D
- Guidelines to design skimming wells proposed

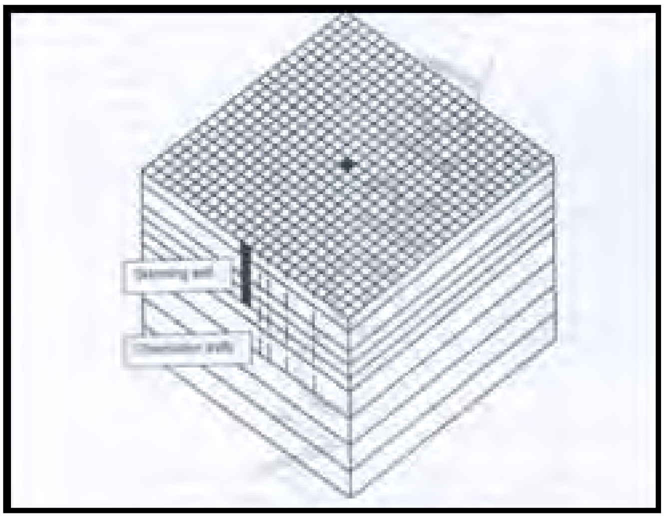


Figure 12.2.13. Schematic configuration of simulation setup: Asghar et al. (2001).

There is an interface between saltwater and freshwater. So when you pump out water the salt interface may go up. This action could be simulated for preventing saltwater intrusion. The application is called the provision of skimming a well. Similarly, water could be collected through lateral pipes or radial pipes. For this, we can prepare guidelines and find solutions. So I have touched upon some technical problems of groundwater to share with you. Allowing for questions I conclude.

Thank you very much!