The need for an integrated approach

by T. Vaishnav

Land and water resources are so intrinsically linked that it is impossible to study or try to manage one without considering the effects on the other.

BEFORE ANY SCIENTIFIC study of the management of land and water resources can be undertaken, it is of the utmost importance that we first study and analyse the exact nature of the interaction which takes place between these two resources — land and water.

As soon as rainwater falls on the earth's surface, a portion of it is evaporated and, out of the remaining portion, one part begins to flow over the surface of the ground, and joins the streams and rivers, and the other part seeps into the ground to be stored there as groundwater and soil moisture. The exact distribution of how much runs off as surface water and how much percolates into the ground depends on a number of factors. The major factors are the slope of the ground, the intensity of the rainfall, the amount of vegetative cover, and the porosity of the surface and sub-surface strata.

The conditions that favour surface run off are steep ground slopes, high intensity rainfall, an absence or lack of vegetative cover, and relatively impervious surface and sub-surface strata. Obviously, when the amount of surface run-off is high, the quantity of water percolating into the ground will be low. Moreover, as all flowing water causes some erosion of the topsoil, the more surface runoff, the more soil erosion.

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Vigorous planting schemes that are backed by the community will help stem soil destruction.

This interaction between the rainwater and the land over which it falls is very important for the understanding of almost all the problems of land as well as water management. The rainwater flowing over the topsoil dislodges the soil particles causing problems of soil erosion and denudation of the land. When this load of soil particles, or silt, is carried by the flowing water to the rivers, canals, and any hydraulic structures on them, it can cause silting problems.

Erosion and silting

The vicious circle of erosion started with the gradual loss of the natural protective cover of the topsoil by the destruction of the forest for agricultural use and for meeting the fuel and building industry needs, shifting cultivation, deliberate and accidental bush fires, overgrazing, and urbanization. Once this protective covering is lost the topsoil is exposed to the action of the rainwater, which not only erodes the rest of the topsoil, but also drains away the precious nutrients which are needed to support the growth of vegetation. With each passing year, some of both the topsoil and soil fertility are lost, and the condition goes from bad to worse until the point of no return as, unlike water, soil is for all practical purposes a non-replenishable resource.

Once the vegetative cover and the topsoil are lost, there is nothing to offer resistance to the rainwater, to allow it the time to percolate into the ground, and to prevent it from flowing away. In such denuded land almost all the rainwater runs off without recharging the underground aquifers, creating drought conditions. Thus the conservation of soil is as necessary for the conservation of water as for its own sake.

At the same time, the silt load caused by soil erosion enters the rivers and begins to flow with river waters. When this silt load becomes heavy it is deposited in the beds of the rivers, (particularly in the dry season when both the flow of the river and its velocity are low), thus continually raising the river beds and so reducing their discharge capacity. In the wet season this leads to flooding. The measures taken to contain these floods, such as the construction of embankments and dykes, offer no permanent solution: the river beds rise progres-


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Once the natural protective cover is lost, the topsoil is exposed to the eroding action of rainwater.

sively because of the fresh silt deposits each year. Silting is also the cause of the changes in the course of the rivers and of their meandering tendency.

Silting is perhaps the biggest problem in the surface storage reservoirs, which are built at enormous cost, because it reduces both their capacity and their useful life. In some reported cases the reservoirs become useless within 25 years of being built. Silting is also a serious obstacle in the running and operation of canal systems.

Integrated approach

It is evident that the problems of soil erosion: denudation, silting, droughts, and floods, are all part of one and the same vicious circle, which started with the neglect of the catchments or the watersheds. There is a great need, to avoid these endless problems, for an integrated approach in the management of the two resources, land and water, which has hitherto been lacking.

Up until now the management of land has been considered to be mainly the responsibility of the agriculturalists, and the management of water resources the responsibility of engineers, with little or no co-ordination between the two. The management of land and the management of water are so interconnected and interdependent that they cannot be considered in isolation from each other.

Based on the realities of the relationship and interaction between these two resources, the cardinal principle of such an integrated land and water management policy must be the prevention of soil erosion by all means, and the retention of as much rainwater as groundwater as possible, by facilitating the maximum natural as well as artificial recharge of aquifers.

There are many advantages in such a policy. Precious soil resources, along with their nutrients, which are now being lost would be saved. The incidence and severity of the droughts and floods which regularly cause incalculable loss to both life and property, and occasionally bring untold miseries in their wake to millions of people, would be reduced. The storage reservoirs and tanks constructed across rivers at stupendous costs would get new leases of life. It would be easier and less expensive to manage the canals and the rivers. Above all, an enormous amount of water which is now just being lost by evaporation or wasted by simply draining into the sea would be saved and conserved as groundwater for the benefit of the community.

Groundwater vs. surface water

Groundwater is, generally, the purest form of water, and it can be stored in underground aquifers in large quantities for long periods, and at practically no expense. It flows over long distances through these aquifers and is thus available to a very large number of people at their homes and farms. Unlike surface water, it suffers no losses by evaporation and seepage during storage and transmission, nor is it exposed to surface contamination. While surface water projects like dams, weirs, and canals take years to materialize, and at great cost, groundwater can be tapped through boreholes in a matter of days at moderate cost, and near to the place of its use. Unlike the controls for the running of the canals, which lie in the hands of departmental supervisors stationed at far off places, boreholes can be operated at the will of the consumer.

Managing change

This issue brings together different policy options and case studies which consider some of the alternatives for the management of water supply and sanitation systems. Views from Botswana, Indonesia, Ethiopia, and Finland make important points about integrating water supply management, enabling communities to finance and manage their own supplies, and about identifying the kind of entrepreneurial spirit in a local person that will get a new system off the ground or rehabilitate an old one. Non-theme articles include participatory health education and a new pipe-lifting device for maintaining Bushpumps.


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Surface water projects take years to materialize, are expensive, and have wide-ranging environmental implications.

The most noteworthy feature about groundwater is that unlike other mineral resources, it is replenished naturally, and if our scientific knowledge could help us to maintain a balance between its use and replenishment a perennial supply could be assured.

The management of surface waters is, on the other hand, difficult, costly, time-consuming, and wasteful of water.

Big surface storage reservoirs and their distribution systems not only submerge large areas of land, but they also result in complex adverse environmental situations. Their construction usually creates problems in human ecology, as large numbers of people are displaced by the inundation of the river basin, and need to be resettled. The social and cultural disruption of life that results, including resettlement processes, is complex and enormous. Even the physical accumulation of a large body of water itself produces stresses in the land structure. It affects the underground water table and results in water logging, salinity, and the infertility of the land, necessitating elaborate and expensive drainage and soil reclamation measures.

In most cases, the anticipated benefits of such surface water projects are never realized in full, and the annual return on the capital outlay is low. Probably the most serious problem is in the field of public health. Invariably the incidence of malaria, schistosomiasis and other diseases with water-borne phases rises, the control of which remains elusive. Also, in many cases, projects on international rivers have turned into sources of dispute between the countries sharing the river waters.

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turned into sources of dispute between the countries sharing the river waters.

Concerted efforts need therefore to be directed towards conserving more and more water as groundwater, and towards developing and using groundwater resources optimally. To achieve this objective, it would be necessary to:

- carry out extensive geophysical and hydro-geological investigations in the nature and extent of the underground formations and aquifers;
- carry out tests to learn the limits of the safe pumping of groundwater without excessive depletion;
- provide agricultural extension services for the benefit of farmers, so that they can get technical guidance and loan assistance to drill boreholes, and to purchase pumps and other inputs; and
- arrange for an uninterrupted supply of cheap power to run the water pumps.

Soil and water conservation measures such as contour bunding, terracing, and deep ploughing should be undertaken along with the construction of percolation tanks, detention weirs, and gully plugs. Suitable deterrent legislation against burning grass or bushes, overgrazing, and felling trees should be enacted and strictly enforced, and vigorous afforestation drives with full community participation should be launched. In the case of arid lands in particular, all rainwater would be progressively harvested for growing whatever crops are possible; if nothing else, then grasses and bushes. All this will help to augment groundwater resources and use and boost agriculture to a great extent. At the same time it would help reduce considerably the silt problems in water bodies and hydraulic structures.

Apart from facilitating the natural recharge of groundwater, artificial or induced recharge must be encouraged wherever possible. The first and the most important study to be undertaken should be to locate aquifers that are suitable for storing rainwater in large quantities. A 1973 UN study on groundwater storage states that artificial recharge will soon represent the only hope for tapping additional water resources in many semi-arid and arid regions where conventional sources of water supply are now being used at nearly their total capacity.

Cheap power

The main barrier to developing groundwater more fully is the shortage of adequate cheap power to run water pumps. This problem could be solved if solar and wind energy were fully harnessed. Most of the South is endowed with plentiful solar radiation and wind throughout the year. It is therefore potentially rich in this respect, and offer tremendous scope for the use of solar and wind energy in the running of water pumps.

So far two types of solar-powered pumps have been developed: thermal and photovoltaic (electrical). The technology applied to the development of both the above types is quite advanced and is undergoing continuous refinement. Such pumps are already in operation in some countries in the South.

A lot of research is needed before these pumps can be perfected for local conditions and their cost brought down enough to enable their use on a large scale. This is the area where a lot of patient work and persistent effort and experimentation is required and so poses a challenge to scientists, engineers, and technologists.

The same is true of the windmills developed so far in the South. It should be possible to design cheaper and smaller windmills, appropriate for local wind conditions, which could irrigate the small landholdings that the majority of small and marginal farmers in the South operate. ●

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Next issue

The April issue of *Waterlines* is co-ordinated by Jamie Bartram and Guy Howard from the Roben's Institute, and looks at the Transmission and Control of Cholera. Articles are from José Hueb of WHO, M.S. Islam and O.M. Bateman of the Institute for Diarrhoeal Disease Research in Bangladesh, Ann Storey of the Roben's Institute, and Francis Mulemba and Pierre Nabeth in Malawi.

Letters to the Editor

Dear Editor,

I was interested to read the article 'Wood: A local option for handpump bearings' in the October issue, but thought that it should have included one important reference: the basic ITDG text on this subject, John Collett's 'Oil-soaked bearings: How to make them'.

Using the ITDG approach, a World Bank research project carried out wear tests on a variety of wooden bearings in 1978. (Sternberg, Yaron, *Testing of wood bearings for handpumps*, World Bank P.U. Report RES 13, February 1978.) Not surprisingly, softwood and non-lubricated bearings did not perform well. Oil-impregnated hardwood (*bubinga*) bearings, however, running on standard 0.5-inch galvanized pipe as a pivot, worked very well, showing virtually no wear after 2 million simulated pumping cycles under a 150lb test load. The pivot showed some surface polishing, because the galvanizing was partially stripped off and formed a wood/oil/metal layer on the surface of the bearing, but this may actually have resulted in lower friction, compared to the original zinc surface. The bearings were kept dry, so the effect of dampness and swelling was not examined (a good initial fit was ensured by re-reaming the pivot holes after impregnation, as recommended in the Collett paper).

The concept appeared promising, but as you know the Bank's later VLOM research focused on improving commercial products and did not pursue the investigation of this type of locally-fabricated component.

These days, I believe that better water resistance could be achieved by, for example, impregnation using polyurethanes with highly penetrating solvents, but this might adversely affect the lubrication effect of the oil.

I believe that wooden bearings have a distinguished history, from propeller shafts on World War I battleships to crankshafts in some early Mercedes cars. I think you should encourage further exploration of their use in VLOM-type pumps (and possibly on other items of village technology), as purpose-made plastics tend to be expensive unless the production volume is extremely large.

Richard Middleton
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