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
Washington, D.C.