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WATER RESOURCE MANAGEMENT IN INDIA : ISSUES AND DIMENSIONS*

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Water has a pre-eminent position among the natural resources. Though fixed and limited in quantum, it is fortunately a renewable resource. Thus the issue of resource exhaustion - that is so central in mineral resource exploitation - does not arise here sharply, possibly with the exception of the following two situations:

(1) depletion of groundwater stock because of excessive withdrawals for irrigation, civic and industrial uses;

(2) siltation of water storage reservoirs when new dam sites in a river basin are unavailable.

In a way, this brings us nearer to the highly current issue of sustainability of irrigation-based agriculture. Under irrigated farming the problem of sustainability arises, *inter alia*, from (*i*) damage to groundwater aquifers from the intrusion of saline and brackish waters unfit for irrigation and (*ii*) development of waterlogging/salinity within canal commands. While the problems of depletion and damage to groundwater reserves have led to demands for the creation of groundwater regulating agencies of the state, the waterlogging problem brings us to the vital question of drainage.

Waterlogging and Drainage

Poor drainage in canal tracts has been the bane of major irrigation works in the Indian sub-continent. Cumulative seepage of canal waters tends to raise groundwater to the crop root zone before long. The process is hastened in the absence of investment in canal lining. In flat topography, canals themselves impede surface water drainage after a downpour. Other normal development activities, like building of roads and railways, and flood protection embankments aggravate surface water drainage. In the absence of requisite investments forthcoming for drainage purpose (including cross drainage), waterlogging becomes inevitable. Two following tendencies hasten this process.

One is the emergence of a sharp deviation in irrigated crop pattern in project commands from the one contemplated by the project planners in their project design. A hallmark of this deviation is the farmer's marked preference for heavily-irrigated crops like paddy and sugarcane over lightly-irrigated crops of pulses, oilseeds, coarse cereals, etc., which are, acre for acre, much less remunerative. The deviation has been reported by many paper-writers in our Group, especially in the upper reaches of canals of the Deccan. As irrigation application per unit of land area rises above the level visualised by the project planners, field percolation losses shoot up and water table rises faster.

*This keynote paper is written in a specific context, namely, to facilitate discussion and deliberations on the subject of water management at the Golden Jubilee Conference of the Indian Society of Agricultural Economics. In writing it, the author profited from a reading of the several papers submitted by scholars on the aforesaid subject. Due references are made to these in the paper. To distinguish them from the cited works listed at the end of the paper, the names of these authors are indicated in italics in the text

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The other tendency on the part of the farmer is to consciously over-water the crop during the course of an irrigation operation. This is essentially his behaviouristic response to the uncertainties of canal supplies, which are partly due to natural diminution in river flows on account of drought and partly due to mismanagement (including unauthorised use of canal water) of the canal distribution system. This is indicative of his desire to store extra water in the crop root zone till his next turn for watering comes. Evidently, it is more prevalent among farmers served by protective canals which are inherently designed to provide far less than the requisite number of waterings at which full yield potential of a crop is realised. Needless to say, when the two tendencies reinforce each other, the field percolation losses shoot up well above the envisaged level.

Outside the engineering circles it is not duly realised that establishing a network of man-made drains is a costly proposition. An ideal drainage system (that includes field drains) is probably no less costly to construct and maintain than the canal system itself. This raises the issue of viability of investment in drainage network. Evidently, the viability prospects are better under modern, high-yielding agriculture. In one paper *(R.K. Panda and G.C. Kar)*, we have reassuring results in this regard, though these are an outcome of ex-ante analysis based on a comparison of well-drained and ill-drained tracts within Mahanadi Delta command area.

Here, one may raise the question of cost-effectiveness of horizontal versus vertical drainage. Vertical drainage with tubewells is now considered a more cost-effective option (Chawla and Sharma, 1984). In fact, vertical drainage as part of conjunctive use of groundwater and surface water is now the watchword of the Indian planners. The question is: how do we promote conjunctive irrigation within canal commands? Before pursuing this question, it is better to make some concluding observations about the wasteful water practices of the Indian irrigation.

Wastage of Irrigation Water

As for wasteful use of irrigation water at the farmer's level, four aspects of such wastage need to be distinguished for a proper appreciation of this phenomenon. One pertains to the escape of water to drains during the course of its transit from the outlet to the field because of lack of channel supervision by an irrigator. The second wastage arises because of recourse to field-to-field irrigation in the absence of field channels that connect individual fields to the canal outlet. The third aspect of wastage is the surface run-off of irrigation water because of lack of field levelling. And the fourth is the problem of over-irrigation. The wastage of the second and the third types are being eliminated through the on-going Command Area Development (CAD) Programme that commenced in the early seventies. The first one being a minor problem, we better concentrate on the wastage due to over-irrigation, and explore if it can be curbed by appropriate pricing of irrigation water.

Both from social and private angles, irrigating fields beyond the requisite level is a detrimental thing. Over-irrigation in the case of public canals has been rationalised by some observers by drawing attention to (*a*) the existence of area-linked water tariff and (*b*) the large uncertainties of canal supplies. Likewise, over-irrigation in the case of electrically-operated, private tubewells/pumpsets in some areas has been traced to the changeover from variable to fixed (*i.e.*, flat) power tariff in which electricity billing is linked to the horse power of the motor only. Thus 'irrational' behaviour of a farmer has been explained away in terms of structure of water/power tariff, with the clear implication that the behaviour would be rational under a variable water/power tariff that links billing charge to volume of water/units of electricity consumption.

The empirical evidence on the farmers' irrigation application by volume and depth of watering in each irrigation operation is scanty. The limited survey data that one comes across is usually unsatisfactory on two counts. Either information only on number of waterings for a crop is gathered from respondent farmers, or volume of irrigation water used is inferred through indirect methods, *e.g.*, in the case of farmers served by public tubewells, the estimates can be made from the reported expenditure on irrigation and the volumetric water tariff in force. The examination of some survey data reveals the following picture.

From an on-going field-based study in the Sriramsagar (formerly Pochampad) project, *Y. Sarojini* reports that in five villages located in the head reach of a distributory of Kakatiya Canal the twenty-five sample farmers over-irrigated their fields to the extent of 8 to 17 per cent - there was 10 to 14 per cent under-irrigation in the case of tail-end farmers. Prihar and Grewal (1988) report an average of 32 waterings for paddy crop by a sample of 40 Punjab farmers during 1983-84 as against the recommended level of 24 waterings (this finding is also reported in *A.J. Singh and A.S. Joshi*). In the case of 84 Punjab farmers owning electric tubewells, Gurcharan Singh (1987) found over-irrigation to the extent of one-fifth above the recommended level. In contrast, Sharma (1984) found significant under-irrigation in the case of 230 private electric tubewells in Uttar Pradesh. This result is in agreement with the National Council of Applied Economic Research (NACER) (as reported in Pal, 1985) and NSS survey data for Uttar Pradesh for the mid-seventies (NSSO, 1984, 1985). From these two large-scale surveys, it is found that each irrigated hectare of crop area in the mid-seventies in India received, on the average, nearly three waterings. Keeping also in mind that waterings from public irrigation works, like canals and public tubewells were deficient in timing, this cannot be described as a state of adequate irrigation, leave aside over-irrigation.

Likewise, my scrutiny (Dhawan, 1989, pp. 58-60) of the puzzling phenomenon of over-irrigation reported by some scholars (Patel and Patel, 1969; Datye and Patil, 1987) in respect of public tubewells of Uttar Pradesh which sell water by volume, reveals serious shortcomings in the methods of analysis employed by these scholars. If direct measures of estimating the volume of water application were to be used, the puzzle of over-irrigation by farmers paying for tubewell water by volume vanishes. Finally, on the matter of over-irrigation we must bear in mind two things. First, Indian farmers, unlike farm research scientists, are not equipped with instruments which either measure the volume of water actually applied to a field or indicate the extent of wetting in field soil profile. Therefore, one must not take a very strict view of some margin of over-irrigation by a farmer under the actual field conditions. Second, the recommended norms for crop watering lack sanctity for an entire State to the extent these are for a given soil-climatic situation. After all, both soils and water conditions are quite varied in each State.

It is a very naive expectation that raising the pitch of tariff for canal water would help in combating the problem of water wastage or over-irrigation by the farmers. When tariff is presently linked to crop area only (or it is a lump sum amount as in Tamil Nadu), farmers do not gain any tariff remission by achieving any economy in canal water use. Unfortunately, in the Indian conditions of small and fragmented land holdings it is patently uneconomic to change the current tariff basis to one of volume of water actually used by a farmer. For one, the cost of metering water supply to every parcel of land in an Indian canal command is prohibitively high. For another, the administrative feasibility of such a metered water supply system is rather low. After all, the principal consideration in shifting from variable to fixed power tariff in the case of electric pumpsets in north India was the difficulty of collecting the power bills as per installed meters which were too often tinkered with by the farmers.

Preventing Groundwater Depletion

Over-exploitation of any resource creates anxiety both among its users and the non-users, the latter being often more forceful in giving vent to their apprehensions as to how the larger interests of the community may be adversely affected by such over-exploitation. Now and then, alarm bells are sounded in the popular media about the hazards of over-use of groundwater. N.S. Randhawa, the Director General of Indian Council of Agricultural Research (ICAR), has expressed an apprehension that Punjab may become a desert again if the State farmers persist in using groundwater for growing heavily-irrigated paddy in the semi-arid conditions of the State. Similar forebodings have been made earlier for sugarcane growing Meerut district of West Uttar Pradesh.

The empirical evidence on over-exploitation of groundwater resource in India is confusing. The area statistics of our groundwater potential and its exploitation indicate a high order of groundwater exploitation but without any sign as yet of over-development as per the State level data. However, the like statistics in volumetric terms, as compiled by the Central Groundwater Board (CGWB), reveal that the bulk of our groundwater potential is still untapped. This mixed state of affairs is symptomatic of lack of firmness in information with regard to our groundwater data base (Dhawan, 1989). This should make us wary of contentious claims with regard to groundwater development in India. In all likelihood, stories of gross over-exploitation of groundwater or its depletion are no less exaggerated than the CGWB's claims that groundwater is still a highly unexploited resource.

A tell-tale mark of groundwater resource being under pressure is continual recessionary trend in groundwater table. *Singh and Joshi* report that water table in Punjab is receding at the rate of 0.3 to 0.5 metres per year. A declining water table is not conducive to a growing agriculture.

Indian hydrogeologists have been repeatedly urging the State Governments to enact suitable groundwater regulation laws. But legislative intervention is going to be of little avail in the particular conditions of small and fragmented land holdings of India. This may largely explain why no State legislature (with the exception of Gujarat) has enacted any legislation on the lines of the model bill circulated by the Centre in this regard way back in 1974. This author believes that pragmatism requires recourse to indirect measure for preventing groundwater depletion in low and medium rainfall regions. Two useful instruments in this regard are: (*i*) abandonment of the existing policy of gross underpricing of electric power for electrically-driven pumpsets and (*ii*) replenishment of groundwater resource through extensive development of surface irrigation works in low rainfall areas because a large fraction of such waters, supposedly lost in transit, end in groundwater table. This brings us to the issue of extensive versus intensive irrigation systems.

Intensive versus Fxtensive Irrigation

If water is abundantly available, as in eastern India, its intensive use per unit of arable land area is worthwhile both from private and social angles. But whenever it is scarcer than land resource, as in much of northern, western, southern and central India, its use per unit of area ought to be on an extensive basis. Such an extensive irrigation policy can be justified on grounds of productivity, equity, stability and sustainability. For water-short regions, the issue of intensive versus extensive irrigation has arisen in the shape of heavily-irrigated versus lightly-irrigated crops. Most notably, scholars associated with the Gokhale Institute of Politics and Economics (V.M. Dandekar, Nilakantha Rath and Ashok Mitra) have been forcefully questioning the wisdom of promoting sugarcane cultivation in Maharashtra State through public canals.

As the income elasticity of demand for sugar is presently high in India, the demand for sugar is growing rather rapidly. If Maharashtra, which is now the number one state in the production of mill-made sugar in the country, is to curb sugarcane raising on public canals, one may rightly ask: how do we go about meeting the growing sugar needs of the economy? I have been pleading for a shift in central sugar location policy away from the Deccan to northern India where water endowment vis-a-vis land is much better, and where sugarcane is indeed a superior crop to wheat-paddy sequence (per unit of irrigation water as well as per unit of crop area). The Gokhale Institute scholars, however, feel that once extensive canal networks are created for promoting the cultivation of lightly-irrigated crops, the seeped-in canal waters can sustain sugarcane cultivation when withdrawn through private investments in dugwell irrigation. This, then, brings us to the question of development of conjunctive use of waters within the commands of surface irrigation works.

Conjunctive Irrigation

Conjunctive irrigation has come to connote private groundwater development within public canal commands. This speaks volumes for the motivations behind the objectives of such irrigation. Indian canals on the one hand are inherently very leaky systems and on the other inefficient in meeting timely water needs of the farmers. It is well-known that only a small fraction (0.25-0.40) of the canal waters released from the headworks are fruitfully utilised by plants (for meeting their evapo-transpiration needs), and the rest is mostly lost to groundwater table. Surface water planners hope to recover these seeped-in canal waters via rise in private well irrigation within canal (and tank) commands. Such recovery would not only achieve vertical drainage in the surface irrigation works but also enable canal irrigators to overcome the basic weakness of Indian canals, namely, their supply-determined instead of demand-determined (as in the U.S.A.) water scheduling. That is to say, the farmers' ability to accomplish irrigation operation on time and in requisite quantity improves manifold, more so if they are being served by canals with following characteristics:

(1) protective canals;

(2) canals in which tail reaches are poorly served for a variety of reasons (over-appropriation of canal waters in the head reaches; insufficiency of canal waters, especially during drought; unauthorised use of canal waters in the upper and middle reaches, etc.),

(3) one or two-seasonal canals;

(4) canals having crop zoning aimed at restricting crop pattern.

The rise of large-scale private tubewell irrigation in the northern protective canals of Punjab, Haryana and West Uttar Pradesh following the advent of high-yielding variety (HYV) seeds is an excellent example of conjunctive use of water resources. Many paper writers *(M. Atchi Reddy and T. Thyagarajan; J.S. Sonnad, K.C. Hiremath, H. Basavaraja and S.T. Patil; C. Ramakrishnan and M. Sivanantham; R.P. Singh and N. Srinivas)* report of the same phenomenon in the tail-end reaches of canals elsewhere. These facts indicate that canal water shortage is a prior requirement for the rise of conjunctive irrigation, a point well made by Venkata Reddy (1988). While this reinforces the case for extensive, if not protective, irrigation systems, it also poses the problem of water needs of small and marginal farmers who may find private investment in well irrigation uneconomic. Can their needs be taken care of by other farmers selling surplus well water to them? Or, do we need to provide for a favoured treatment for them in the allocation of canal supplies?

Improving Level of Utilisation

Getting more production and income benefits out of our limited resources of water, land, capital, etc., is an avowed objective of our planning. Some paper-writers *(M. Subbarayan and Ikbal Singh; D.B. Kanade, S.N. Suryawanshi and S.B. Dangat; L.K. Atheeq and J.V. Venkataram; O.P. Chikkara and B.S. Panghal; Rajesh Sharma and S.S. Acharya)* bring out the scope for raising farmers' income through changes in crop pattern. As these potential gains are an outcome of linear programming (LP) exercises, these are unrealistic to the extent the LP models fail to reckon with uncertainties of weather, product prices, dated availabilities of irrigation water, etc. Far more relevant are outcomes based on the concept of watershed management. Several paper-writers *(Katar Singh; B.V. Pagire; V. Prasad, R.I. Singh, B. Singh and S.M. Dingar; V.S. Kulkarni, H.G.S. Murthy and V.R. Kiresur; C. Arputharaj and E.C. Rajayan; Asha Saksena, P.N. Bhargava and T.B. Jain; D.K. Mahandule and Jg.R. Pawar; B. Kumar, S.K. Singla and R.S. Dhawan; R. Rajagopalan and B. Anuradha; D.V. Subba Rao; C.V. Hanumanthaiah and K. Nataraj)* report empirical results of watershed management projects from various parts of the country and with different project content. But few have appraised the viability aspects. In what follows we take up the very vexing issue of capacity utilisation, to which several paper-writers address themselves *(S.K. Gupta; Ashok K. Mitra; M.C. Athavale and K.S. Yadav; K.J.S. Satya Sai; G.C H. Sastry and A.G. Prasad; H.B. Ulemale, M.R. Alshi and C.K. Joshi; Balishter and Roshan Singh; S.S. Sangwan; Mohd. Hasan; Karam Singh, H.S. Sandhu and Nirmal Singh; P.K. Awasthi, J.K. Gupta and A. Mishra; R.C. Mondal and S.K. Chakravorty).*

The basis for adjudging utilisation of irrigation potential is of questionable merit. Therefore, one should be wary of simplistic estimational work in this regard. One needs to separate myth from reality in this area where the public concern is often quite misplaced because of simplistic readings of the estimates of unutilised capacity. Till the end of the Fifth Five Year Plan, the Yojana Bhavan published its own estimates of utilisation of created irrigation potential on the tacit assumption that minor irrigation potential is always fully utilised. This working assumption has led to an erroneous belief among the pro minor irrigation lobbyists that there is in fact full capacity utilisation in this segment, and that the phenomenon of under-utilisation is confined solely to major irrigation works. That serious problems of under-utilisation are also encountered in minor irrigation works is little realised outside well-informed circles. This plagues not only minor irrigation works in the public sector but also those in the private sector.

Much of the unutilised irrigation potential of major irrigation works of the nation is of a fictitious nature. This is especially true for works located in low and medium rainfall regions of the country, namely, southern and western India. Here, irrigators utilise the bulk of the reservoir water for growing paddy, sugarcane and other heavily-irrigated crops, especially in the upper and middle reaches of a canal system. This results in a drastic curtailment in total irrigated area - mainly at the expense of the farmers in the tail reaches - giving rise to an apparent picture of under-utilisation of created irrigation potential that is conventionally expressed in terms of irrigable area. The overall production consequences of this shift in crop pattern are likely to be adverse indeed because of the fact that crop productivity per unit of irrigation water is lower under heavily than lightly irrigated crops. For reasons of productivity and spatial equity in production gains, the deviation in crop pattern needs to be prevented.

Time and Cost Overruns

A number of inefficiencies arose during the course of irrigation project implementation. Of these, time and cost overruns in the case of major works, as revealed by audit reports, have caused much dismay. The cost overruns in many projects appear truly mind boggling till one takes pains to correct the actual costs incurred for the continual price inflation - some perceptive irrigation planners have tried to bring out that the price rise in respect of inputs used in major irrigation projects has been about 3 per cent higher than that in the case of foodgrains. A better measure of the execution inefficiency is the time overrun, which can in turn be largely ascribed to inadequate project funding by the State Governments. The question is: why this project under-funding? Too many project starts, some of them even not approved by the Planning Commission? Too much leakage of resources in the shape of kickbacks? Pre-emption of limited funds in executing World Bank-aided projects which are, acre for acre to be irrigated, far more expensive than other schemes? The diversion of investible funds into providing subsidies to existing irrigation projects working at a huge loss?

The financial management of public irrigation works is unquestionably dismal. These works (with the sole exception of Uttar Pradesh) do not generate sufficient revenue to cover even their working costs, not to speak of recouping the high investment costs. A major factor in this is the policy of gross under-pricing of canal water by every State Government. Unfortunately, the political climate for bringing farm resource prices in alignment with resource costs is becoming more and more unfavourable, thanks to the gathering momentum of farmers' agitation in recent years. But do politicians realise the myopia of continual under-pricing of farm resources? In the case of irrigation, preventive maintenance gets ignored and repair activity becomes a patchwork job. This takes its toll in two ways: (I) poorer irrigation service to the farmers and (2) mounting up of the replacement investments which have to be provided for an utmost priority basis - this further erodes the pool of investible funds for new and on-going projects.

Achieving Economy in Water Use

When water is scarce, one may rightly ask if there are irrigation methods that reduce water use without adversely affecting crop yield. Sprinkler and drip irrigation are two powerful technologies for achieving substantial economy in water use. We have three papers on drip irrigation *(N. Nagaraj; S.L. Deshpande and V.N. Autkar; Y.P. Mahalle, B.D. Bhole and P.N. Bidwai)* and two on sprinkler irrigation *(A.C. Gangwar, S.K. Sharma and D.D. Gupta; B.S. Tomer, S.N. Singh and R.S. Nandal)*. The scope for the diffusion of drip method of irrigation is mainly limited to horticultural crops (mainly fruits) for which it is best suited. But these crops have a small share in the agricultural sector of developing economies. More promising is the case for sprinkler irrigation. What are the stumbling blocks here? Its unsuitability for paddy which is our single most important irrigated crop? So far, it has been primarily used by the farmers owning wells equipped with power pumps. How do farmers having access only to surface irrigation sources (canals and tanks) adopt it? What about its indivisibility? Does its promotion require more subsidisation by the state?

Another route to economy in water use is adoption by our irrigators of the scientific water management practices. According to Rajput (1988), who is Project Co-ordinator of the ICAR-sponsored field irrigation research in India at over 30 farm research stations/ agricultural universities, abandoning the common practice of keeping land under submergence throughout the growth period could reduce water requirements by 20 to 40 per cent. (This relative economy is comparable to the one expected from sprinkler irrigation.) What do we do to diffuse these scientific water management practices? Is it simply a case of strengthening the extension education network? What are the farmers' own perceptions about the scientific water management practices? Will the formation of water users associations, or introduction of *warabandi* system of water distribution, prove helpful in the adoption process?

In passing, I would like to mention about the need for effecting savings in our conveyance losses which are undoubtedly high. The current policy is to line the canal systems - it has become a necessary design component for all projects for which World Bank aid is sought. Canal lining is a costly proposition. It is a must in arid areas underlain with brackish waters. But do we need it in areas where the spectre of groundwater depletion exists?

Coping with Water Abundances/Droughts

Spatial unevenness in our water bounty is inevitable for a country of continental dimensions. What is truly striking are the temporal variations in our water availability, both within the agricultural year and from one year to the next. Whereas spatial unevenness necessitates heavy investment in long distance transfer of water from the more endowed to the less endowed tracts, temporal unevenness makes sizable investments in water storage works imperative.

The expert assessment till recently has been that irrigation potential of our water resources would suffice for three-fifth of our crop area. Under the New Water Policy, this coverage could rise somewhat, provided the new concept of water planning beyond a river basin is duly translated into ground reality. This is, however, no easy task from the political viewpoint as water is a State subject in the Indian Constitution. We need to be realistic, and be prepared for acrimonious inter-State disputes on water transfers as well as water sharing of common rivers. But entertaining visions of Ganga-Cauvery Link or of creating Garland Canals with the aid of Himalayan waters, are pipe dreams. Instead of Garland Canals for the Deccan plateau, this water-short region has better promise from the diversion of huge surplus waters of the West Coast rivers.

Containing floods is a very arduous task, more so in a chronic flood-prone area like the flat east Gangetic plains. Here, raising embankments along river courses appears a questionable course of protective action. The techno-economic feasibility of large detention reservoirs in the Himalayan catchments of these rivers does not look all that encouraging. Likewise, the indirect detention of flood waters via increased afforestation of the fragile Himalayas requires a very high order of mutual co-operation among the four riparian countries of the Indian sub-continent. And the option of flood plain zoning is of little practical value in a densely populated area having high incidence of flood hazard.

The ill effects of drought can be better coped with. While the foremost need here is the maintenance of buffer stocks of foodgrains, dips in crop output during drought can be reduced through the following two-part strategy.

First, we should use our stock of groundwater in drought-prone areas on the buffer stock principle; we deliberately under-exploit our groundwater resource in normal times, so that we can overdraw groundwater during drought years. Logically, this demands greater emphasis on development of major surface irrigation works to take care of our normal irrigation requirements. This brings us to the second part of our strategy, namely, building storage works with extra capacity for storing excess inflows of above-normal rainfall years. These excess inflows are to be used like buffer stocks of foodgrains. It may, however, be noted that addition of such extra capacity to a proposed reservoir would not only add to the cost of irrigation but also mean added height to dams. Since increase in dam height usually leads to more than proportionate land submergence, this aggravates the problem of rehabilitation of dam oustees in which our past record is poor *(H. Hemachandrudu and K.R. Chowdry)*. Ours being a well settled country, the State Governments already find it problematic to suitably relocate dam oustees. Thus we face a trade-off here: gain in drought proofing at the expense of greater uprooting of the people and increased submergence of land and forest cover in the river catchment. At the moment, the dice is loaded against bigger reservoirs (*Sitesh Bhatia*).

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