Utilizable water resources*

Garg and Hassan[1] have argued that the utilizable quantity of water resource estimated by the practitioners of water resources engineering (practitioners, as distinct from academicians) – 1110 BCM estimated by CWC, 1209–1255 BCM by NCIWRD, and 1122 BCM by MoWR – are all wrong; the error is as high as +66 to +88%; the utilizable water resources are just about 668 BCM; and therefore even with a low-demand scenario with total demand estimated at 897 BCM, there will be a shortage of 229 BCM. Obviously, the shortage will be more if the demand is more. In short, according to Garg and Hassan, India faces the prospects of an acute water shortage never envisaged before.

Practitioners of water resources engineering are used to articles from 'independent experts' who (a) seek to show technocrats in the Government as incompetent, having committed or about to commit some grave error, and (b) forecast some imminent catastrophe. Many have acquired an instant 'renowned water expert' status by taking that line. Over time, one learns that it is neither necessary nor useful, and not even possible, to reply to every such article. However, when two civil engineer-academicians from reputed institutions argue that the CWC and all others went wrong by as much as +66 to +88%, one has to take note.

There are two independent issues here. One, whether the CWC indeed made the error as alleged by Garg and Hassan and if so, the magnitude of that error, and two, whether Garg and Hassan's own estimate of 668 BCM is better than the other estimates so far.

Estimation of the utilizable water resources is a complex task because of (a) uncertainties in estimation of virgin river flow due to lack of adequate and reliable data of abstractions, (b) uncertainties in the estimation of replenishable groundwater resources – which, unlike the surface flow, cannot be measured directly, (c) difficulty in estimation of return flow from abstractions, and (d) continuous and two-way transfer of water between surface-water domain and groundwater domain, which makes it impossible to quantify the overlap in these two domains. The above-listed issues are resolved by making several simplifying assumptions. The set of these assumptions constitutes the estimation methodology and the estimate of utilizable resources will depend on the estimation methodology adopted. Different agencies employing different methodologies will necessarily arrive at different estimates. What one looks for is a convergence. The recent estimates, 1110, 1209–1255 and 1122 BCM can be expressed as 1182.5 ± 72.5 BCM, or $1182.5 \pm 6\%$, and that is a good convergence for something which is based on measurements that could have a measurement error of more than ±6%.

The Garg and Hassan estimate is well outside this band. The main thrust of their argument is that the estimate of utilizable surface-water resources includes some contribution from groundwater also, because the river flow during the lean season is groundwater reappearing in the river; and therefore it is incorrect to add the 'replenishable groundwater' resources to utilizable surface-water resources estimated from river-flow measurements, because then a part of the groundwater resources – the one that appears in the river – gets counted twice. It is for the CWC to re-examine and modify or confirm, and explain to others, their methodology. This correspondence examines the Garg and Hassan methodology, and their conclusions.

Garg and Hassan have assumed that the utilizable surface-water resources equal the surface storage capacity. In the last paragraph on p. 935 they write, 'It is fairly appropriate to assume that the utilizable water resources can be taken as the sum of the storages (excluding the evaporation losses) and, as discussed earlier, 91.5% of the replenishable groundwater resources'. They have not explainned why it is 'fairly appropriate' to assume that. In table 4 of their article, they have applied this assumption to compute the utilizable water resources. They have taken the evaporation losses as 20% of the storage capacity and in column 5 of table 4 have computed the utilizable water as the sum of 80% of surface storage capacity, and 91.5% of replenishable groundwater. The former adds up to 308 BCM, the latter to 313 BCM, and their estimate of the total utilizable water resources at this stage is 621 BCM.

In columns 6–35 of the same table they have done a basin-wise water-balance analysis, eventually estimating the return flows as 54 BCM to surface water and 83 BCM to groundwater. Accounting for the return flow, they have modified the earlier estimate of utilizable surface-water to 362 BCM and utilizable groundwater to 390 BCM, a total of 752 BCM. Finally, they have assumed that it will not be possible to transfer water from a surplus basin to a deficit basin and therefore, they have restricted the utilizable water in each basin to either the demand or the utilizable water, whichever is less, thus reducing the final estimate of the utilizable water resource of India to 668 BCM.

One may have reservations about these computations in columns 6–41 of table 4, but it would be a serious digression to comment on that, as the impact of all that is only to change 621 to 668 BCM, a change of just 47 BCM. The concern their article has caused amongst the water-sector professionals is about a purported error of 454 BCM (1122–668) and to start a debate on the correction of 47 BCM would amount to debating about the pennies while losing sight of the pounds.

Their 'fairly appropriate' assumption that the utilizable surface-water resource equal the storage capacity is wrong, as this completely ignores the surface water utilization from non-storage schemes, known as run-of-the-river schemes. Even if it is argued that the lean season run-of-the-river is entirely groundwater appearing in the river – though they have not said so, and if they do, then that can be debated – even then they have completely ignored the monsoon run-of-the-river utilization. Since this utilization is often much more than the storage capacity in a basin, a major part of the utilizable surface resource has been left out of their computations, leading to a serious underestimation of utilizable water resources.

The best way to illustrate this is with examples. Consider the Upper Yamuna river basin, i.e. Yamuna from its origin up to Okhla barrage in Delhi. The mean annual flow in this reach is 13 BCM. As of now there are no storages in this reach of the river. Therefore, according to the logic of Garg and Hassan, the surface-water utilization in this basin as of now should be nil. Reality is that the utilizetion is already close to 9 BCM, which is about 70% of the mean annual flow. Except the environmental flow releases of 10 cumecs, which over the year add to 0.32 BCM, almost the entire flow of Yamuna is extracted at Hathnikund bar-

*The views expressed in this article are my personal views.

rage 228 km upstream of Delhi and diverted into two great canal systems known as the Western and Eastern Yamuna canals. Only during high floods does some flow escape out of the basin. This too is proposed to be stored and put to use by construction of three storages, Kishau, Lakhwar-Vyasi and Renuka, with a combined live storage capacity of about 2 BCM. The storages will enable additional utilization of 2 BCM, bringing the total utilization from surface sources to about 11 BCM, more than five times the total live storage capacity.

Another example. In the Ganga up to Haridwar there is only one storage, the Tehri dam, which has been completed only two years ago (in 2005). But the Upper Ganga canal system taking off from Bhimgoda barrage near Haridwar has been irrigating almost one million ha for more than 100 years, without any storage. Likewise, any number of more examples can be given from other basins. Upper Yamuna and Ganga were deliberately chosen as examples because these are practically 'no storage' basins, and yet have a large surface-water utilization. Moreover, this utilization is there for all to see, without the need for any data. The point is – a significant part of the surface-water utilization comes from non-storage schemes, and Garg and Hassan have completely ignored that.

Thus, it seems that the Garg and Hassan estimate of 668 BCM as the total utilizable water resource is way off the mark and on the lower side; because they have equated utilizable surface resource with live storage capacity in a basin, completely ignoring the non-storage utilization. Therefore, one may relax and start breathing normally again, as the water shortage scenario they have painted is incorrect.

Concluding their paper, Garg and Hassan have pointed out that theirs is only a quantitative analysis, which assumes that all the available water will be of acceptable quality. This is indeed the most crucial aspect of water resources planning. Many analysts have pointed out that agriculture is already supporting as many livelihoods as it possibly can; land holdings are reducing in size with every generation and this is the main reason for rural poverty, as it is not possible to support a family with land holding as small as 1 ha. As the population continues to increase, it is necessary to reduce the pressure on agriculture as a means of livelihood and provide more employment opportunities in the industrial sector.

Thus, a massive increase in industrialization, and with that a massive increase in urbanization, is inevitable. But the performance of the Indian industry in effluent treatment – particularly the small-scale industries – is most unsatisfactory. Likewise, the performance of the urban local bodies in sewage treatment is also nothing to be proud of. It is not impossible that there will be water in the rivers and in the aquifers, but its quality will be so bad that it will be of no use.

Garg and Hassan have recommended that all possible storage works be completed on priority basis. Temporal skew in precipitation and river flow is smoothened out by storing the water in reservoirs and aquifers. As the climate change accentuates the skew, storages will become even more important than what they are as of now. Just as temporal skew in precipitation is smoothened out by storages, spatial skew is smoothened out by transferring the water from where it is available to where its availability is less. That is what inter-linking of rivers is all about. Thus, storages and interlinking are two major actions that are necessary to deal with the temporal skew and spatial skew respectively. To implement these to the fullest extent, it would be necessary to overcome the dogmatic opposition to river valley projects by 'renowned water experts'.

1. Garg, N. K. and Hassan, Q., *Curr. Sci.*, 2007, **93**, 932–941.

CHETAN PANDIT

National Water Academy,
Central Water Commission,
Government of India,
Sinhagad Road,
Khadakwasla R.S.,
Pune 411 024, India
e-mail: cmpandit@nic.in

Garg and Hassan reply:

Considering the complexity of the problem and in order to compare the estimates, we have adopted a similar methodology[1] for the estimation of water utilization as that of the NCA – comprising storages plus river diversions (the regenerated groundwater flows into the rivers due to recharge from natural precipitation) and groundwater recharge due to water use. After analysing the previous studies it was found that the CWC had also adopted the same methodology and directly adopted the figures of the utilizable surface water from the NCA (table 3 of the paper[1]) – comparison of utilizable flows of identical basins) without going into the assumptions, etc. The CWC estimated the utilizable water resources as 690 BCM from surface water plus 418.54 BCM (CGWB assessment 1983–84) from groundwater (table 1 of the paper[1]) to approximate the total utilizable water resources as 1110 BCM. It has also been shown by us[1] that the utilizable surface water of 690 BCM was the sum of the live storage of 240 BCM (after deducting losses) and 450 BCM (the regenerated groundwater flows into the rivers due to recharge from the natural precipitation during the non-monsoon period for river diversions, following NCA). Since 418.54 BCM was estimated as the new updated figure of total groundwater recharge (corresponding to 800 BCM (450 (natural) + 350 (irrigation recharge)) of NCA), the CWC should have subtracted 450 BCM from 690 BCM before adding it to 418.54 BCM, and therefore overestimated the water utilization. Thus, data from the NCA were juxtaposed on the data from the CGWB assessment (1983–84) without going into the assumptions by the CWC and has been clearly shown[1]. All the subsequent reports like NCIWRDP or National Water Policy of India, have taken the value of 690 BCM as utilizable surface water from the CWC and therefore are matching within tolerable limits.

The NCA report categorically states: 'In the absence of comprehensive observations and data compilation the figures in the chart represent only broad magnitudes and should be treated merely as indicative and not definitive'. Therefore, it was necessary to incorporate the significantly reduced updated value of the replenishable groundwater resources of CGWB and unlike the CWC, we have corrected the estimate of the utilizable flows with the new estimate of 432 BCM (the sum of the natural recharge and the additional recharge from canal irrigation system) of the CGWB (1995)[1]. Unlike the NCA, the CGWB kept the entire replenishable groundwater to be utilized through pumping, except for a provision of around 36 BCM to the river to maintain river ecology. Unlike the CWC, we have corrected the estimate of the utilizable flows with the new estimate of the CGWB (1995) (keeping no flows for non-monsoon river diversions) and 385 BCM from storage (including identified future storage projects) along with the additional return flows (following NCIWRDP (1999) approach) on full development[1] and estimated the utilizable water resources as 668 BCM. CGWB (2006) has again re-confirmed its earlier estimate of 432 BCM, as it is now updated marginally to 433 BCM.

The foregoing clarifications clearly show that unlike the CWC, there is no mixing up of data on the utilizable groundwater resources by us. The water-use balance in 1997–98 of 629 BCM has already been discussed by us[1] and would not be repeated here. The estimation of 1123 BCM has also not been calculated as stated by the authors of the correspondences, but as a sum of 690 BCM (surface water) + 433 BCM (groundwater). It is assumed that all the storage figures of the CWC are at 75% dependability, although the total replenishable groundwater estimates are for normal rainfall. The reduction on account of silting is not considered and it is also assumed that all the water, including the return flows is of acceptable quality. The water utilization may increase through non-conventional methods and may be tried with proper assessments.

The monsoon river diversions were also not considered by the CWC and therefore, it is not discussed by us[1] in order to compare estimates with similar methodology. Also, we could not obtain data on monsoon diversions, generating from around 100 h of rainfall, to meet the irrigation demands without storages at 75% dependability.

The illustrative examples of Pandit certainly seem to be wrong. Historically, it was the low flows that were diverted either from the Ganga or Yamuna rivers with the help of temporary or permanent structures called as weirs, and the dropping shutters on the weirs remain dropped during the monsoon season to pass the monsoon floods. The policy was also limited to extensive irrigation. It is only recently (around 1990) that the weirs were remodelled as barrages to maintain the pond levels during the monsoons and to divert some flows depending upon the matching of the monsoon flows with the irrigation demands. If the regenerated groundwater flows into the river are not available, then the diversion structures may not be suitable for the assured irrigation and may not be economically viable.

The river diversion data, as claimed by Pandit on the utilizable river diversions, is of the order of 70% of the mean flow. If one takes it seriously, it would mean that the utilizable river diversions alone would be of the order of 1308 BCM ($0.70 * 1869$ (mean annual flow)) without any storage. The total utilization would be of the order of 2125 BCM (1308 (river diversion) + 385 (surface storages) + 432 (groundwater)). The 20% return flows would make the utilizable flows to 2550 BCM. The utilization can be further increased by considering non-conventional methods like transferring 250 BCM by inter-basin transfer and 36 BCM by artificial groundwater recharge. It would lead to a total utilization of the order of 2893 BCM, more than normal breathing space even with no population control!

The foregoing discussions and table 3 of our article[1] conclusively prove that the CWC had also adopted the same methodology as that of the NCA and directly adopted the figures of the utilizable surface water from the NCA, but data from the NCA were juxtaposed on the data from the CGWB assessment (1983–84), without going into the assumptions by the CWC. We have also used the same methodology as that of the CWC, but have corrected the mistake of the CWC in our calculations. There is an overestimation of the utilizable water resources of India ranging from 66 to 88%, as analysed in the article[1].

1. Garg, N. K. and Hassan, Q., *Curr. Sci.*, 2007, **93**, 932–941.

N. K. GARG[1,*]
Q. HASSAN[2]

[1]*Department of Civil Engineering,*
Indian Institute of Technology,
New Delhi 110 016, India
[2]*Department of Civil Engineering,*
Jamia Millia Islamia,
New Delhi 110 025, India
**e-mail: nkgarg123@yahoo.com*