A Dam-Made Disaster

How large dams and embankments have worsened flooding in India

by Himanshu Thakkar

"With water brimming well past the permitted levels at the Ukai Dam, and the skies showing no sign of relief, the engineers apparently threw open the reservoir's sluice gates. Water then did what water does. It surged downriver, swallowing this city of three million people like a hungry beast."
The New York Times

India's monsoons are legendary. Very heavy rains can come in concentrated periods, making the runoff particularly hard to manage with traditional engineered solutions. This has not prevented the Indian government from trying to use big dams, embankments, floodwalls and the like to control floodwaters. When these efforts fail, they can fail catastrophically. This is a story of one of those failures.

Near the end of July 2006, the annual 3-4 month long monsoon had been pummeling the South Gujarat region for about a month. The first seasonal increase in the water level at the huge Ukai Dam was noticed on July 2. The dam, located about 80 km upstream from the city of Surat, was designed with adequate storage capacity (7.092 billion cubic meters when it was completed in 1972) and a comfortable flood cushion (1.332 billion cubic meters, or almost 20% of the reservoir, was intended to remain unfilled until the end of monsoon). Residents of Surat – a thriving city known for diamonds, silk textiles and interesting cuisine – should have had little to fear.

But just a week into August, the most disastrous flood in the city's history hit like a runaway train. By the evening of August 8, the dam was releasing over twice the amount of water that the river downstream could carry. That carrying capacity is further reduced on high tide days, as was the case on that fateful August day. High releases continued for over four days. By the time the floods subsided, at least 120 people were dead, hundreds of others missing, over 4,000 cattle dead and more missing, and economic losses estimated at US$49 billion.

The *New York Times* reported: "With water brimming well past the permitted levels at the 350-foot Ukai Dam, according to official records, and the skies showing no sign of relief, the engineers apparently threw open the reservoir's 21 sluice gates. Water then did what water does. It surged downriver, swallowing this city of three million people like a hungry beast. The diamond lanes of India became a warren of muck and ruin."

As revealed by analysis undertaken by my organization, South Asia Network on Dams, Rivers & People,[1] the Ukai flood disaster was entirely avoidable, and entirely due to the mismanagement of Ukai Dam by its operators.

What went wrong?

The dam's mismanagement was as wide as it was deep. First, they allowed the reservoir to fill past the allotted "flood storage" point, then waited too long to begin releasing water. Second, critical information on the carrying capacity of the Tapi River did not seem to be part of the equation of the dam's water releases. And third, siltation in the reservoir had reduced the dam's storage capacity.

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[1] http://www.sandrp.in/floods/dam_floods_0806_pr.pdf

Add to this dangerous mix the fact that 21% of the live storage capacity of the reservoir was full even before the monsoon started.

When we compared the Ukai reservoir levels just before the monsoon to previous years, we found that they were at their highest levels in four years. In the days before the flood, dam managers knew that especially high rains had hit the basin in recent days. They could have restored an adequate flood cushion by beginning much higher water releases on August 1. Yet releases even just two days before the flood were shockingly low. On top of all this, the authorities knew the flood cushion had shrunk from siltation, and had recommended a review of its operation. This likely would have resulted in an even greater flood cushion requirement. This was not done.

The Ukai Dam story was repeated in many river basins across India in 2006, including the Mahi, Sabarmati, Chambal, Narmada, Krishna, Godavari and Mahanadi basins. Everywhere, sudden high releases of water from dams (many of them having high pre-monsoon storages) were the prime reason for most of the flood damages in these basins. And in most cases, the floods occurred less than half way through the monsoon.

The floods of 2006 were in no way unique. There have been many other instances where dams have led to flood disasters, including the Bhakhra, Hirakud, Tawa-Bargi, and Damodar dams, to name a few. Over the years, India has seen its flood damages increase, at the same time that the total area supposedly protected by flood-control engineering projects has grown. It is noteworthy that most these high flood events occurred after the flood control projects were in place. In two of India's most flood-prone areas, the Ganga and Brahmaputra basins, local agencies have documented large increases in the area prone to floods – in some cases, as high as a 60% increase.

There are a number of factors that are contributing to this alarming trend. Some of the main issues include the following.

Lack of Operating Rules

It is often claimed by the government that most of India's more than 4,000 large dams bring flood control benefits, yet far too often the results have been increased flood damages, usually because of mismanagement. The operation of dams for flood protection is not carefully regulated. The Government of India's National Commission on Floods (NCF) noted in 1980: "Most of the reservoirs completed in the country do not have any specific operation schedules for moderation of floods." In the Ganga basin, the Kangsabati Dam is supposed to reserve more than a quarter of its reservoir for flood storage, yet the report says, "The Kangsabati reservoir has no operation rules drawn up so far, nor have the moderation benefits been evaluated." The report also critiques management of dams on the Damodar River and others.

A similar case can be made about the other major flood protection measure widely adopted by India, namely embankments (also known as levees). Embankments can offer partial protection for limited periods, but when they do break – and they certainly do – the damage is much larger, the floods more sudden, of greater intensity and longer duration. There is the additional problem of people who live within the embankments, which number in the millions in India. These people face the prospects of floods almost every year, and since they have not been provided any proper rehabilitation, they have no option but to stay within the embankments to cultivate their land, mostly in post-monsoon months.

Box 1

DAM APPROVED TO CONTROL "MAD RIVER" FLOODS MAKES A BAD SITUATION WORSE

The Government of India approved the Pagladiya Multipurpose Project in Assam in 2001, citing flood control as a major benefit. The dam is being built on the Pagladiya River, a tributary of the Brahmaputra. This is a "multipurpose" affair, meant to establish "flood control" over 40,000 hectares, and irrigate 54,000 hectares. In 2001, the project was expected to cost US$123 million. Today, its estimated cost has more than doubled to $257 million.

The Pagladiya project came in for sharp criticism last year in the Parliamentary Standing Committee on Agriculture. Praful Bidwai, who served on an Environment Ministry "Expert Committee" on river valley projects in 1996-98, states: "Pagladiya literally means 'mad river' because it changes its course wildly, drastically and suddenly. This is the result largely of seismic factors that cause mountainous masses of earth to shift position, creating landslides, huge silt flows and floods. The effect is compounded by deforestation and other man-made factors. A minority within the committee, including me, opposed the project because no dam could possibly address the root cause of the floods or the river's shifting of its bed by kilometers at a time. A three-km-long dam would be useless, for instance, on a river that changes course by 30 km in 4 years! The project, we argued, is doubly irrational because in the name of 'irrigation', it would create waterlogging in places."

The project was approved under pressure from the Government and irrigation lobbies. Today, the dam partly complete, the same "mad river" is creating havoc through floods and by depositing coarse silt on fertile paddy fields, causing local shortages of food.

The Parliamentary report notes the large amount of sand the river carries "gets deposited on the bed, raising its level. As a result, it easily breaches the banks, causing catastrophic damage. In 2004 too, [the] Pagladiya changed its course and converged with another river. According to the "Pagladiya Dam Project Affected Area Agitation Committee," a local community group, the project will result in the loss of ancestral homes of 33 villages, in order to benefit 37 villages further south. Several other groups have held demonstrations seeking a halt to the dam as it may create a serious flood problem in tribal-dominated areas. They say that the survey for the dam was done in 1968 and since then the environment in the area had undergone drastic changes, making the construction of the dam irrelevant in the present context. The groups stress that small check dams in the tributaries in Nalbari district would be a better option, and would also help with irrigation.

Changing the character of floods

Flood protection measures in one area can increase the problem in another area. The Report of the Government of India's National Commission on Floods (NCF) notes: "Local or narrow functional approaches often conflict with the interests of the basin or the region or the nation as a whole. For example, construction of embankments in certain areas can lead to increase in flood levels upstream and downstream." Embankments are basically flood transfer mechanisms: they quickly transfer the floods from a given area to downstream areas. The floods resulting when embankments are breached are very different than a natural flood. Embankment floods are sudden, have greater destructive power, often bring a huge quantity of sand, and remain for longer periods than would be the case without the embankments. Large-scale breaches in embankments have been common in some of the more flood-prone states.

The NCF reports that there has been no credible assessment of the performance of the embankments on any river. The commission notes, “The annual benefits from embankments were, therefore, by and large, a matter of overall opinion of some individual, with no supporting data. We were, therefore, reluctant to draw any conclusion from the trend of such opinions.”

R. Rangachari, the former second most senior official in the India’s Water Resources Ministry, has noted: “There are many problems associated with embankments. Unfortunately there are few scientific evaluations of their actual performance under different types of rivers in representative regions.” Similarly, while dams may or may not moderate floods in the downstream areas, they certainly lead to submergence in the immediate upstream areas. The backwaters behind dams affect additional areas in the flood season. Similarly, a flood caused by the opening of a dam's spillway gates is very different in character than a naturally occurring flood. The dam-related flood generally comes fast, without warning and hence is more destructive.

Floodplains mismanagement The UN University study[i] of trends of floods in Bangladesh notes: “In the discussions about the history and causes of floods, there is more and more evidence that human influences within lowlands significantly contribute to the increasing dimension of flooding and flood damage. The construction of lateral river embankments or the cutting off of feeder channels isolate the large river systems from open water bodies and swamps that were natural storage areas for surplus water but are gradually being converted into agricultural land. According to Khan et al (1994), in the Ganga-Brahmaputra floodplain alone approximately 2.1 million ha of wetlands have been lost to flood control, damage and irrigation development.”

Tables 1, 2 &3 below show (for the years for which official data is available) how the average annual damage due to floods have increased over the years in spite of building of flood control measures in Bihar, Uttar Pradesh and in the Brahmaputra basin.

Table 1

Average Annual Damage due to Floods in Bihar

Period	Total Area affected, Lakh Ha	Crop Area affected, Lakh ha	Total damage at constant prices, Rs Lakh
1950-65	8.81	4.43	861.92
1966-70	10.82	5.85	1184.08
1971-78	21.30	8.85	4588.57

Source: NCF

Table 2

Average Annual Damage due to Floods in Uttar Pradesh

Period	Total Area affected, Lakh Ha	Crop Area affected, Lakh ha	Total damage at constant prices, Rs Lakh
1950-65	16.80	7.84	1229.48
1966-70	20.12	10.42	1730.16
1971-78	30.00	16.64	4550.81

Source: NCF

Table 3

Flood Damage Trend in Brahmaputra Basin

Period	Average Annual Area flooded (m ha)		Flooded crop area as % of total inundated area	Average Annual no of people affected, m	Average annual damage Rs M
	Total	Cropped			
1953-59	1.013	0.1	8.85	0.86	58.6
1960-69	0.75	0.16	21.33	1.52	75.7
1970-79	0.87	0.18	20.69	2.00	151.8
1980-88	1.43	0.40	28.05	4.55	1445.2
1999-2005	1.07	0.38	35.65	4.586	7171.7

Source: World Bank, 2006

It is clear from the above tables that the embankments in Bihar, UP and Assam have failed to reduce the damages due to floods. In Bihar, on the contrary, the average annual damage has been increasing over the years, till 1978. The situation after 1978 is not likely to be any different, though information for this period is not readily available. Similar is the situation in Brahmaputra basin.

The Way Forward

A comprehensive flood-management program should revolve around improving flood-coping mechanisms and flood-preparedness. Some key areas that must be addressed in India include sustaining and improving natural systems' ability to absorb floodwaters; improving dam management, and instituting clearly defined and transparent operating rules that are stringently enforced; improving the maintenance of existing flood infrastructure rather than spending money on new dams and embankments; undertaking a credible performance appraisal of existing infrastructure in a participatory way, and removing embankments that are found to be ineffective; and producing transparent disaster management plans intended to be implemented in a participatory way. Perhaps most importantly, India needs to assess the potential impacts of climate change on rainfall and on the performance of flood-related infrastructure, and begin planning for the necessary adaptation to the changing climate.

In addition, the two following programs, both of which are already being tried in India, deserve much wider implementation:

River Basin friends: People-driven flood forecasting

The River Basin Friends is a people's network of more than 300 organizations located in the Ganga-Brahmaputra-Meghna basin. Official flood forecasting from the central government is often insufficient to predict impacts at the local level, and the information cannot usually reach people in vulnerable locations. So River Basin Friends began its own initiative to commence an early flood warning mechanism which reaches people all the way downstream in Bangladesh. It has more than 1,000 members of different disciplines, living in different parts of the basin, each of whom helps circulate flood forecasting messages from upstream locations to downstream locations, using phones and email. People in the central hub in Assam collect information from different sources, and the peoples' network in upstream locations of the Brahmaputra basin process and analyze it. The final flood early warning messages are then formulated for different vulnerable locations and disseminated to these locations.

This has been going on quite effectively at least for the last three years. More in-depth study of this remarkable initiative needs to be done, as it has the potential to provide lessons for many other communities.

BOX:2

Impact of climate change

Unfortunately, there has been no systematic assessment of the impact of climate change on hydrology of the rivers and the performance of water resources projects in India. SANDRP recently asked (under India's Right to Information Act) two of the Government of India's premier organisations, namely the Central Water Commission and the Central Electricity Authority, if any study of impact of climate change on water resources projects has been done. The answer from both was no.

However, some of the proponents of large dams have been trying to push greater storage capacity through large dams in the name of reducing the impacts of climate change. Such blind advocacy cannot benefit anyone. On the contrary, a performance review of water storage projects shows that on average in each of the past 12 years, storage capacity equal to at least 6.5 Sardar Sarovar reservoirs remain unutilized. Similarly, a study of siltation of existing storage capacity shows that India may be losing 1.32 billion cubic meters (BCM) of storage capacity in each year, when gross addition to storage capacity is about 1.98 BCM per year. This indicates that we may be losing two-thirds of created storage capacity due to siltation. Nothing credible is being done to arrest the siltation. Climate change is only likely to increase siltation due to glacier melt and also greater frequency of high rainfall incidents.

Based on available information on climate change, both smaller storage reservoirs and underground storages are likely to perform more efficiently, because they are less vulnerable to damage from floods, and losses through evaporation and siltation.

Groundwater Recharging to Manage Floods: The Central Ground Water Board of the Government of India completed a study that estimates the additional groundwater resources that could be available by arresting the surplus monsoon run-off and storing in sub-surface aquifers. The salient features of the plan are:

⇒ The estimated surplus monsoon run-off in India's 20 river basins is864.7 billion cubic meters (BCM). It would be possible to create surplus potential storage of 59.06 million hectares by saturating the aquifer. Out of this storage, it would be possible to retrieve 436.4 BCM.

⇒ However, on the basis of the available surplus monsoon run-off, which is not uniform in time and space, the ground water storage that could be feasible has been estimated as 214.2 BCM, of which about 160 BCM is considered retrievable; and

⇒ The above resource could be harnessed to create an irrigation potential of 32 million hectares.[2]

Reduction of even a fraction of this quantity of 214.2 BCM from the rivers during floods would have tremendous impact on the floods in the river basins. However, there has been no attempt to realize this potential. The Government of India's Finance Minister in February 2007 proposed spending US$419 million on a new groundwater recharge scheme. It remains to be seen how the scheme will be formulated, how it would be implemented and what is the impact.

In conclusion, there is mounting evidence that structural measures have been largely ineffective in its claims of controlling floods, and in fact, have worsened flooding in many parts of the country. Yet the state and national governments in India – with support by international agencies like the

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[2] Union Water Resources Minister in Lok Sabha Dec. 10, '01

World Bank, the Asian Development Bank and the Japanese Bank for International Cooperation – is pushing for more, not less of the same structural solutions. The opportunity provided by the report of the World Commission on Dams in reviewing planning and decision-making frameworks for large dams appears to have been completely lost on India's water managers. The people, however, are fighting against such measures in a number of places. One notable example is growing opposition to building embankments in Bihar. The mounting opposition to India's River Linking Plans is another indication of this trend. SANDRP has called for a national, independent enquiry into the issue of flooding in India during the 2006 monsoon, especially with regards to sudden releases from dams. We are calling for more transparency in dam operations, and a review of operating procedures. We hope that public pressure from these various campaigns, along with the good example of initiatives like people-centered flood forecasting and groundwater recharge projects, will help lead India toward a more sensible approach to floods.

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[i] *Floods in Bangladesh: History, Dynamics and Rethinking the Role of the Himalayas*, Thomas Holfer and Bruno Messerli, United States University, 2006