tion between matters relating to *Deen* and *Duniya*. The process of secularization is fed by the search for knowledge which grows into science-based knowledge. By this process, human beings endeavour, on the basis of knowledge, to grapple with the problems of political, economic, social and cultural structuring of societies. In Europe, the secularization process produced in time Renaissance, Enlightenment and Juristic humanitarian universalism. We can easily discern similar processes at work in the story of our own civilization.

State for totality of national interest

It is important to remember that the process of secularization was powerfully helped by the elaboration of natural laws instead of laws derived from sanctity of religion. When, in the midst of this process, there emerged the Modern Nation State, the question arose, and certainly arises in our country with a particular sense of legitimacy, about the nature and character of our State: Is State an instrument for enforcing divine laws? Alternatively, is State an instrument for the enlargement and protection of the totality of national interest transcending religious or denominational divisions? It is from these considerations that there arose the need for the State confining itself to the affairs of this world, and thus being secular rather than being an instrument of any particular faith or dogma.

It may be noted that the process of secularization is accelerated in the measure that a State, citizens and society are governed by laws enacted through the democratic processes. There then emerges a "law-governing State" and "law-abiding citizens". In our country, we have laws and procedures relating to crime; we have laws relating to evidence; we have laws governing transfer of property and about taxation. All these are secular laws concerning the affairs of our world in India. In this view of the matter, it is normal and natural to have uniform laws governing all the citizens of the Republic of India.

If the words secular, secularism and secularization are to be understood as part and parcel of a universal process of secularization of the human mind, then we have inflicted enormous damage on the nation-building process in India, by a totally unacceptable and false translation of the word secular and secularism by equating them to the doctrine of religious tolerance expressed in the words like *Dharmanirpekshta* and *Sarva Dharma Sambhava*. These translations have produced great schizophrenia in our politics which, in time, has produced the situation with which we are now actually confronted in Punjab and Kashmir. And not merely in Punjab and Kashmir, but elsewhere too, when our politicians of all political parties make their electoral calculations in terms of 'Hindu', 'Muslim', 'Sikh', 'Christian', etc.

There is one more question which needs to be answered: What is the relationship between religion, howsoever defined, and processes of secularization? Is this relationship inherently antagonistic? The answer is no. The process of secularization merely leads to finding the domain of each, both at the level of individual and society and State. That is why the word 'Secular' as we have stated means "concerned with the affairs of this world, not spiritual or sacred". It is to be hoped that if the Republic of India is not to degenerate into a state of anarchy, the time has come to grips with the real meaning of such words as 'secularism' and 'fundamentalism'.

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Context: Tehri Dam

OPINION

Must we have high dams in the geodynamically active Himalayan domain?

K. S. Valdiya

The occurrence of the moderate earthquake of M 6.6 on 20 October 1991 resulting from slipping along active faults in a region cut by many active faults and thrusts, and which has been consistently giving warning signals in the form of small earthquakes of magnitude 3 or less, has once again brought to the fore the question of building high dams in geodynamically sensitive regions. The Uttarkashi earthquake not only killed over 1000 people but also wrecked more than 28,222 buildings, severely damaged another 20,658 houses and also violently shook a large part of north-central India. The Tehri Dam in the Garhwal region of central sector of the Himalaya is taken as an example of the risks involved in building high dams.

A majority of 200-odd hydel projects that have been built or are being constructed or planned happen to be located not far from the seismically and tectonically active zones of faults and boundary thrusts tearing the Himalayan terrain into blocks and segments (Figure 1, Table 1).

The 260.5-m high dam, across the

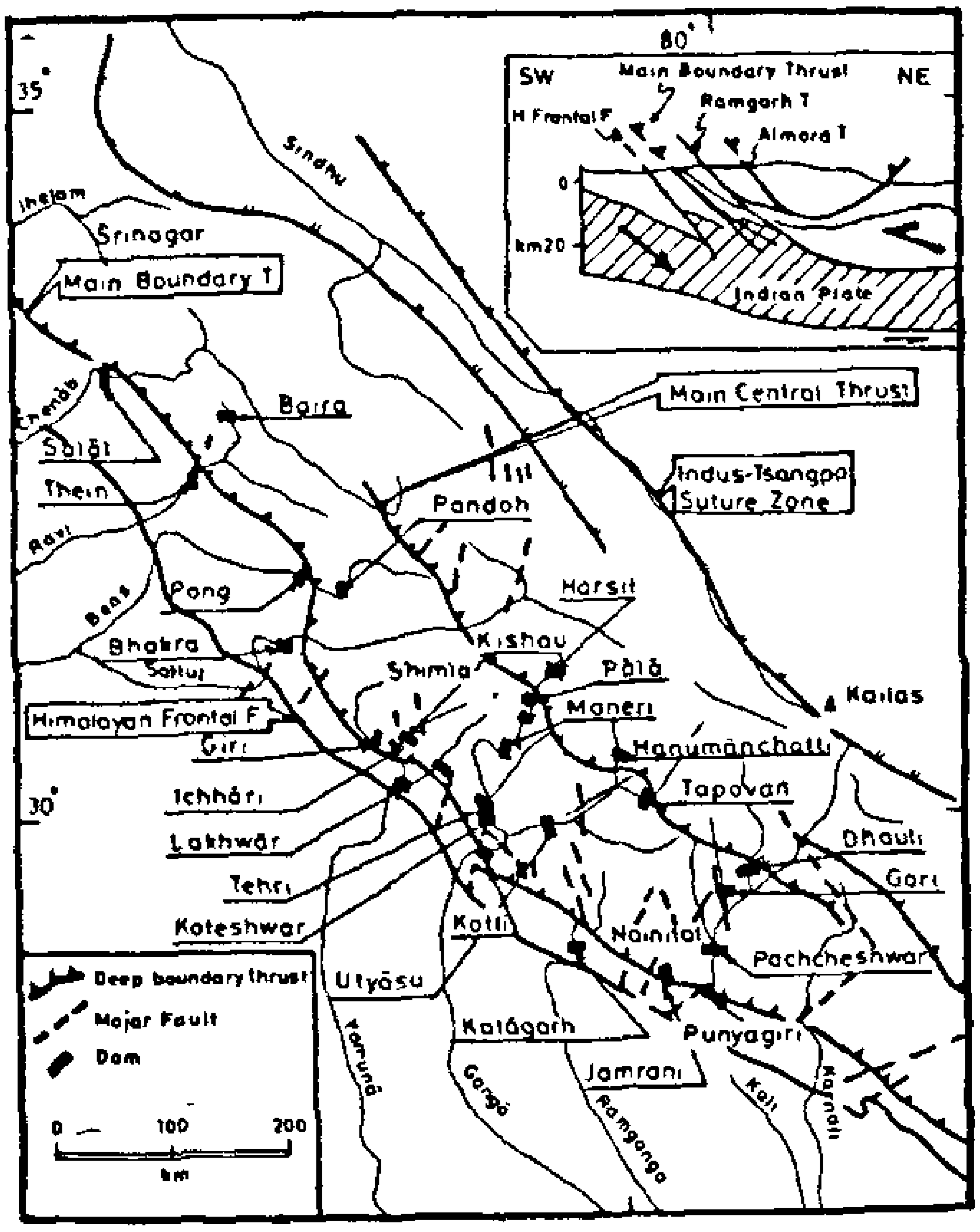

Figure 1. High dams constructed or planned in the Himalayan province happen to be located close to active boundary thrusts and faults.

Table 1. Dams in Himalayan rivers higher than 100 m

Dam	River	Dam height (m)	Volume of impounded water ($\times 10^6$ m^3)	Volume of dam structure ($\times 10^3$ m^3)
Bhakra	Satluj	226	9,621	4,130
Pandoh	Beas	116	8,141	23,310
Kalagarh	Ramganga	126	2,369	13,507
Pong	Beas	133	8,570	
Thein	Ravi	147	3,300	
Kothar	Kosi	155	4,080	
Kishau	Tons	253	2,400	
Tarbela	Sindhu	143	13,687	142,000
Mangla	Jhelam	118	7,250	64,491
Under construction				
Tehri	Bhagirathi	260.5	3,539	
Lakhwar	Yamuna	192	580	

Bhagirathi river, being built at Tehri is close to the active Shrinagar Thrust which has registered a few pulses of uplift in the geologically recent past (Figure 2) and is releasing internal stresses in the form of small earthquakes, felt only by instruments. It is therefore quite natural to be apprehensive about the safety of the dam, tunnels, bridges, buildings and of the wellbeing of the people of the region who have already had the trauma of a natural earthquake and might be threatened with more earthquakes—natural and/or reservoir-induced. *There must be people in the governments of the people for the people who would care for the hapless 86,000-odd people living in the Bhagirathi and Bhilangana valleys whose life would be doomed once the reservoir water rises behind the high Tehri Dam.*

Technical feasibility and economic gains not the only factors

The Tehri Dam is not merely an engineering structure built to benefit the people of the command area but also an artificial construction that will considerably modify the ecosystems and alter hydrological regimes in areas both upstream and downstream in the mountain domain. It is therefore to be viewed not only within the restricted framework of technical feasibility and economic gains to the people of the command and industrial areas, but also to be assessed in terms of the environmental changes it is bound to produce and of the sociocultural stresses and distresses of the uprooted people in the reservoir area in Garhwal. The confidence of the Garhwal people, it may be emphasized, has been shattered by the earthquake of 20 October 1991.

The various dams constructed and being planned in the Himalayan region (Table 1, Figure 1) may be technically very sound in terms of design and construction, and their sites geologically very well-investigated, and possibly there are rare chances of their failures even under adverse conditions. However, what has not been done is the comprehensive evaluation of the effects of impoundment of water on varied aspects of the natural environment, both in the reservoir basins and command areas, and on the fabric of the society of the uprooted communities.

There are three basic infirmities of the Tehri project and the like conceived for the Himalayan rivers: (1) There seem to be no built-in provisions in the plan frameworks for the elimination or mitigation of negative environmental and sociocultural effects, such as restoration of damaged forests, destabilized slopes, etc. (2) Welfare of and benefit to the people living not only in the command areas but also upstream of the dams should be the major consideration and not just the technical feasibility and the capital, which admittedly are important factors. *There should be a firm commitment on the part of the sponsors and builders of dams (governments) for*

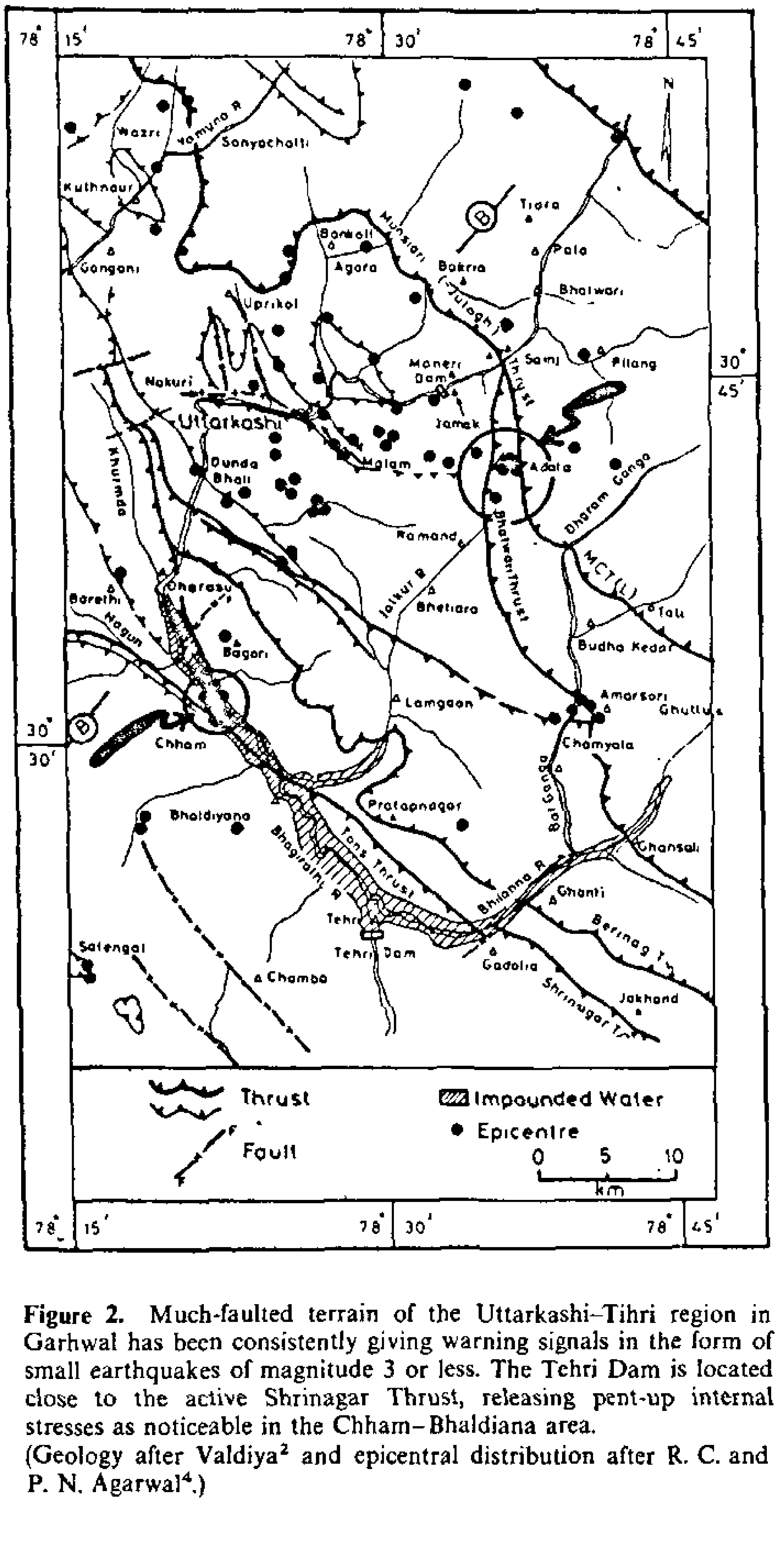

Figure 2. Much-faulted terrain of the Uttarkashi–Tihri region in Garhwal has been consistently giving warning signals in the form of small earthquakes of magnitude 3 or less. The Tehri Dam is located close to the active Shrinagar Thrust, releasing pent-up internal stresses as noticeable in the Chham–Bhaldiana area.
(Geology after Valdiya[2] and epicentral distribution after R. C. and P. N. Agarwal[4].)

sharing the benefits between the communities living upstream and downstream of the dam. (3) There is no projection of financial burden related to (i) resettlement of the displaced persons, (ii) provision of essential services and basic amenities to the relocatees, and (iii) restoration of damaged forests, destabilized slopes, etc. In other words, while computing the cost, no value has been attached to the natural resources that would be lost, the ecological integrity that will be damaged, the people's socioeconomic life which will be traumatically disrupted in the submergence area.

Undeniably the command and industrial areas in western UP and the adjoining region will be greatly benefited—2.7 lakhs ha of irrigated land will be brought under intensive irrigation and 346 MW electricity will be available to towns, cities and industries in the plain. But the 86,000-odd people of the Bhagirathi and Bhilangana valleys will be forced to leave their homes for ever, live in an entirely alien environment and climate with shattered families and broken links, and the people left there higher up the slopes will bear almost the entire ecological and social costs of the project and live in the shadows of dread of recurrent earthquakes.

Critically stressed condition and seismicity

The entire Himalayan domain is geodynamically very sensitive. This is reflected in its seismicity (Table 2) all along the faulted zones, which are quite active[1–3]. By active faults it is meant that horizontal and/or vertical movements on the faults have taken place in the geologically recent times—in the last 11,000 years. The snapping and slipping of rocks on faults generate shock waves, and the passage of ground waves causes damage and destruction. Many of the faults and thrusts of the Himalaya have given rise to earthquakes, some of very high magnitude (M 8.5 or higher).

Intriguingly, the much-faulted Garhwal and Kumaun region has remained seismically quiet for quite some time with regard to the higher-magnitude earthquakes. Surely, the stresses are progressively building up inside, as this segment is being strongly pressed and prodded by the Aravali Ridge of the northward-drifting Indian subcontinent (Figure 3). The Uttarkashi–Tihri region lying directly in the line of this Ridge is therefore in a critically stressed condition. This is evident from the intermittent occurrence of small earthquakes (Figure 2) of magnitude 3 or less, particularly noticed 20 km NW of Tihri as evident from the studies of R. C. and P. N. Agrawal[4] and Khattri and Gaur[5,6].

Take the example of Tihri–Uttarkashi region. The last major earthquake (M 7.6) occurred here in 1828. For over 164 years the stresses have been accumulating progressively. The moderate event of M 6.6 on 20 October 1991 did not relax sufficient strain, so that there is still a very large amount of residual stresses waiting to be released by a major earthquake whose magnitude has to be 8 or higher, in the opinion of Gaur[7]. If an earthquake of magnitude 6.5 releases energy equivalent to the explosive energy of 28,616 tonnes of TNT, then the earthquake of magnitude 8.0 will release energy equivalent to the explosion of 5,686,890 tonnes of TNT, and the event of M 8.5 about 28,615,850 tonnes.

Table 2. Major earthquakes in/or near the central sector of Himalaya

Date	Magnitude	Location	Latitude	Longitude
15 July 1920	X	Delhi	28.5	77.2
1 September 1803	IX	Badrinath	30.0	79.5
	VIII	Garhwal	30.0	79.0
	VIII	Sirmaur (HP)	30.7	77.5
	IX	Mathura	27.5	77.7
1809	IX	Garhwal	30.0	79.0
26 May 1816	VII	Gangotri	30.9	79.0
24 October 1831	VII	Delhi	28.5	77.2
5 March 1842	VI	Shimla	31.1	77.2
	VI	Mussoorie	30.4	78.1
	VI	Saharanpur	30.0	77.5
25 July 1842	VI	Delhi	28.5	77.2
26 September 1842	VI	Delhi	28.5	77.2
11 April 1843	VI	Landour	30.4	78.1
31 March 1852	VI	Meerut	29.0	77.7
11 August 1858	VIII	Shimla	31.1	77.2
11 April 1865	VII	Shimla	31.1	77.2
	VI	Mussoorie	30.4	78.1
25 July 1869	VI	Nainital	29.3	79.4
22 May 1871	VI	Landour	30.4	78.1
	VI	Meerut	29.0	77.7
	VI	Agra	27.2	78.1
2 March 1878	VI	Shimla	31.1	77.2
26 February 1906	VIII	Bajang (NW Nepal)	32.0	77.0
28 October 1916	7.5	Dharchula–Bajang (Nepal)	30.0	81.0
2 October 1937	8	Dehradun	30.2	78.0
	6	Roorkee	29.8	77.9
	7	Delhi	28.5	77.2
10 October 1956	6.7	Near Khurja	28.1	77.7
28 December 1958	7.5	Bajang-Dharchula	30.5	81.5
27 August 1960	5.1	Near Delhi	28.5	77.2
27 July 1966	6.3	Kapkot-Dharchula	29.5	80.1
15 August 1966	5.6	Muradabad	28.7	78.9
28 August 1968	7.0	Dharchula-Bajang	29.7	80.5
19 January 1975	6.8	Kinnaur	32.5	78.4
21 May 1979	6.5	Seraghat (Gori)	29.6	80.3
29 July 1980	6.5	Dharchula (Kali)	29.7	80.5
20 October 1991	6.6	Uttarkashi		

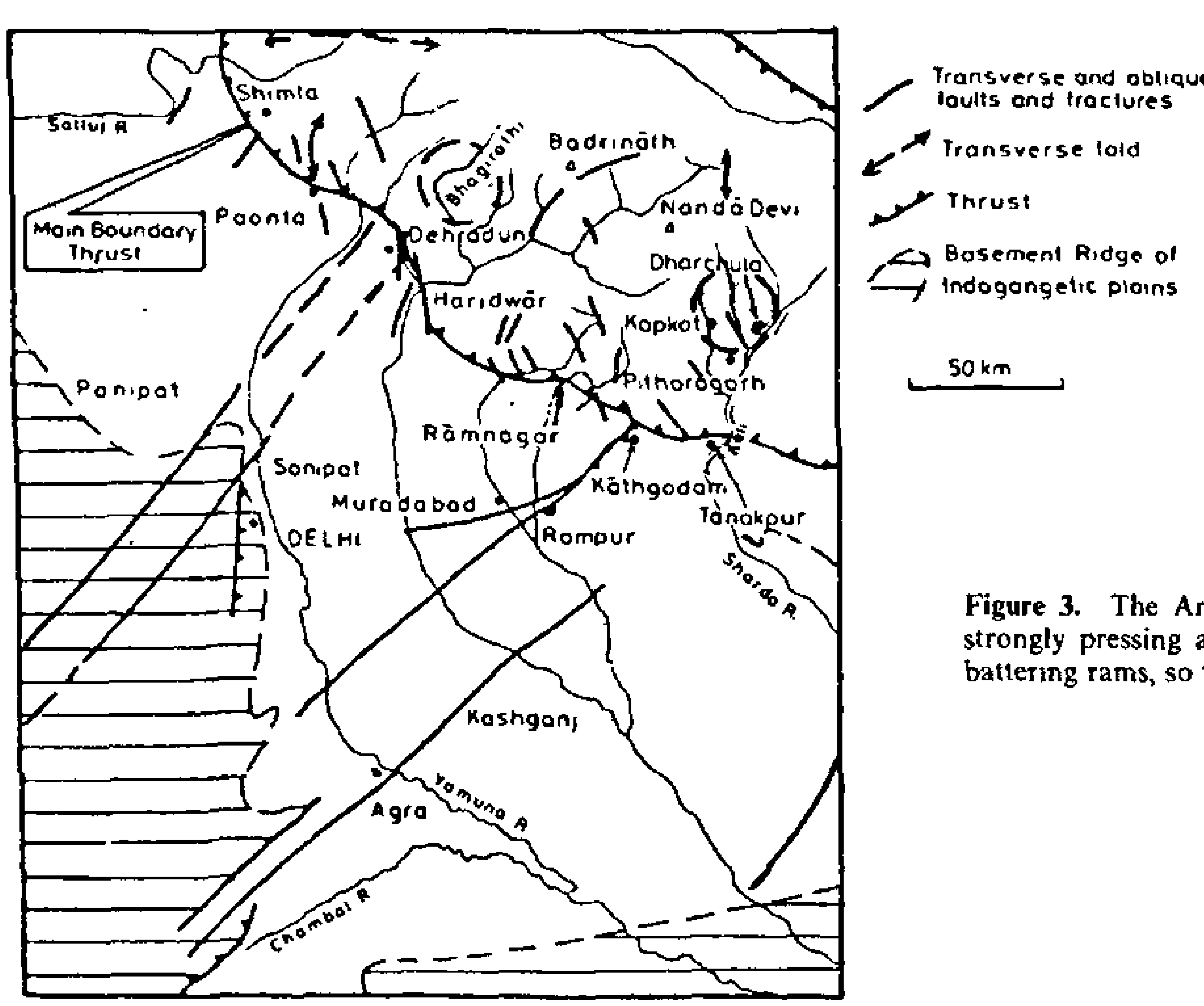

Figure 3. The Aravali Ridge and the Muradabad Fault-block are strongly pressing and prodding the Himalayan orogen like colossal battering rams, so that the regions in their lines are critically stressed.

Even if the area were to be spared of a naturally occurring major earthquake of high magnitude, the impoundment of 3.2 billion tonnes of water behind the 260.5-m high Tehri Dam located in a critically stressed region is bound to cause frequent occurrence of reservoir-induced earthquakes which will make life very hazardous and worrysome.

Reservoir-induced seismicity

The load of the 2.62 million cubic metres of water to be impounded behind the Tehri Dam is estimated to be 3.2 billion tonnes, according to Anil Agrawal. Evidently, the filling of lake water will exert more pressure on the accumulated sediments and generate new stresses underground, promoting seismic movements on faults, particularly the active ones. It is noticed that the stresses build up to the peak slowly over several years after the initiation of the lake filling. And then there is a sudden failure of the ground, releasing stresses in the form of an earthquake. Therefore, there is a decline in the seismic activity. Analysis of seismic data by Gupta and Rastogi[8] and Simpson[9] from a number of reservoir sites all over the world has established beyond doubt that seismicity is induced or increases soon after the impounding of water behind high dams, even in essentially aseismic areas such as Koyna in Maharashtra (1967, M 6.7). As pointed out by Huang Naian[10], there are three conditions necessary for the induced seismicity: (i) the seepage of reservoir water due to existence of passages (such as faults) in the deeper rock-mass — the larger is the areal extent of the seepage area the greater would be the quantity of the water seeping down, (ii) the deeper tectonic conditions such as existence of faults and weak zones and accumulated stresses, and (iii) brittleness of rocks. If all the three conditions are present at the same time, occurrences of earthquakes are induced, otherwise not.

It happens that practically all these conditions exist upstream of the Tehri Dam. Water percolation through the shattered and crushed zones of seismically and tectonically active faults and thrusts — including the recently active Shrinagar Thrust and the shear zones associated with it — would increase the pressure within the water which is filling the empty spaces in rocks at depth, thus triggering slippage or shear failures and cause resultant earthquakes. The infiltration of water reduces the effective shear strength. This will aid the shearing stresses which cause movements along fault planes. Although no riverbed fault at the dam site exists, there are many approximately 10 cm thick and a few 2–3 m to as much as 11–22 m thick shear zones cutting across the phyllites and quartzites that dip 30–50°S/SSW (that is downstream) (according to Nawani *et al.*[11]). Presently the hydrological condition in the drifts indicates tightness of the planes of discontinuities in the rocks and low fracture permeability of 0.63–1.595 lugeon. The shear zones are therefore unlikely to serve as permeable zones. However, in the event of major earthquakes of magnitude 7.5 or above, the possibility of the shear zones opening up and allowing infiltration of water cannot be ruled out. This phenomenon would certainly increase the pore-water pressure under the dam.

Coupled with the above-mentioned phenomenon, there will be addition of vertical stress produced by the load of the reservoir water, plus the accumulating sediments. Consequently, the underground stress regime will be considerably changed. This phenomenon would certainly cause increased seismicity, particularly in the areas of normal faulting related to the Shrinagar Thrust, the Dunda Fault and many tear faults (Figure 2) dissecting the Uttarkashi–Tihri region.

Dam in the proximity of an active thrust

The WNW–ESE trending Shrinagar (Tons) Thrust passes through the vicinity of Tihri (Figures 1, 2). It is an active fault, which has registered many pulses of movements, including uplift of the mountain in the geologically recent past, including in the last 11,000 years. This is borne out by spectacular tell-tale geomorphic features seen *only* in the stretch of the Bhagirathi where it flows south of the Shrinagar Thrust after crossing it — between Vandrakoti near Chham and Uppu east of Bhaldiana, for instance. There are six levels of river-made terraces in this stretch (Figure 4*a*) compared to the normal three elsewhere in the north. These terraces can be best seen in the Tihri and Shrinagar areas also as noticed by Khan and his coworkers[12] and Prasad and Rawat[13]. This fact implies three episodes of uplift on the thrust *quite after* the three uplifts of the whole Ganga catchment in the late Pleistocene period ending 11,000 years ago. The old Bhagirathi, which windingly and leisurely flows in its wide mature valley having very gentle slopes, abruptly flows swiftly through incised meanders and a deep canyon course (Figure 4*b*). The north-flowing streams have extremely steep gradient and tumble down into the Bhagirathi with many rapids and waterfalls. There are huge cones and fans of debris such as at Uppu-Sila (Figure 4*c*) deposited by landslides, triggered presumably by earthquakes related to rather violent uplifts of the massif to the south of the Shrinagar Thrust. The clusters of epicentres of minor earthquakes (microseismicity) at Chham and near Bhaldiana (Figure 2) demonstrate accumulation of stresses in the fault zone.

As a matter of fact, the Nagtibba-Pauri-Nainital mountain massif has been repeatedly uplifted and squeezed up between the Main Boundary Thrust and Shrinagar Thrust (Figure 1).

The 260.5-m high Tehri Dam will come up on a location about 4 km south of the active Shrinagar Thrust. If three pulses of movements have occurred possibly in the last 11,000 years, future movements accompanied by earthquakes cannot be ruled out in future. The dam has been designed to withstand peak ground acceleration of 0.45 g, which an earthquake of magnitude 7.25 would cause. In the event of the major earthquake of anticipated magnitude 8 or higher, which will generate ground acceleration exceeding 1 g (J. N. Brunne of the University of Nevada), this dam will face problems, particularly if the ground cracks up by fissures, and the tight shear zones in the dam site open out and allow infiltration of water. One cannot help being very apprehensive about the safety not only of the structures (dam, bridges, buildings) but also of the people who inhabit the mountain slopes of this disaster-prone region.

Sociocultural impacts

Submergence and resultant uprooting

Cultivable land in the mountains are very limited. According to Moddie[14] on an average 17.5 persons share one hectare of land compared to 2.3 to 5.8 persons per hectare in the plains of UP. The fertile lands restricted to mostly the river terraces occur in the lower levels of valleys close to the riverbeds. When the reservoir fills, these fertile patches will submerge and will be lost for ever. According to the evaluation of Paranjpye[15] about 1600 ha of cultivated lands of 112 villages (Figure 2) will be submerged and more than 85,600 people of 8630 families (but only 13,000 people according to the Project Authority, *Times of India*, 29 May '89) will be uprooted and forced to leave their land for ever. The life of the Himalayan villages is sustained largely by the earnings remitted home by able-bodied young men who temporarily migrate to the plains, leaving their homes wholly to the cares of women, children and aged or disabled men. To allow inundation of the villages of over 85,600 people would be to permit destruction of the homes of the men who fight and die for the country in defence forces, of the women who toil in the field from dawn to dusk, and of the children who grow up uncared for. The mass-transfer of the populations may be an insignificant incidence to the planners a

b

c

Figure 4. Geomorphic evidence indicating that movements have taken place at least three times in the geologically recent times—on the Shrinagar Thrust. a, Six levels of terraces in the thrust zones compared to three elsewhere. b, Narrow Gorge of Bhagirathi as it enters the thrust zone. c, Huge fan of landslide debris of recent origin.

Resettlement of oustees

The proposed compensation package provides for (according to the Bhumbla Report[16]) two acres of developed agricultural land along with a homestead plot of 200 m^2 to some, 0.5 acre of land to some others, and only monetary compensation to the rest. The 2767 acres of land earmarked (Paranjpye[15]) (but not legally/formally alloted) are in the forested Dehra Dun valley in the foothills. One has to see to believe the plight of the relocatees (450 families) and the appalling state of affairs resulting from unbelievably callous indifference of the powers that be. According to Paranjpye[15], 'The amount of cash paid as compensation is insufficient to buy land in other places. Many families have been left out of the compensation scheme. The oustees, being basically farmers, are ignorant as to how they should spend the compensation received in lumpsum. As a result, it will get squandered or swindled by officials or middlemen'.

Naturally there is a crisis of identity, a strong sense of betrayal, acute feeling of rage due to broken promises among the very few people who have been rehabilitated so far.

The relocation scheme should have been taken as an opportunity to raise the living standards of the displaced people, and improve their social organization. The governments are bound to provide a new modern house for every house pulled down, and a new town with all essential services for every village inundated. And the cost of transportation to the new habitats must be borne by those who have caused this displacement. However, the record of rehabilitation in the case of Tehri oustees, as in the cases of hundreds of dams elsewhere in the country (according to Madhav Gadgil[17]), is worse than dismal, if not cruel and callous.

and builders of dams but a calamitous tragedy for the 86,000 oustees.

As stressed by Paranjpye[15] and in the Bhumbla Report[16] there is no comprehensive planning, and little investment of capital for the resettlement of the uprooted people of the Bhagirathi–Bhilangana valleys. The imposition of new lifestyle in new locales with altogether different climatic conditions will be done against the wish of the overwhelmingly large majority of mute people, and without even consulting them (women, children, aged, retired who stay home) regarding the mode of living they are expected to adopt. And this is happening in a democracy.

Thayer Scudder puts it poignantly: '*It is indeed hard to imagine a more dramatic way to illustrate impotence than to forcibly eject people from a preferred habitat against their will*'.

Gamut of likely environmental changes

Putting dams across rivers generates wide range of changes—the normal flow pattern is impeded, the riverine and terrestrial environments are converted into lake environment, and the geological–geophysical conditions are considerably modified. These bring in their trains profound biological, hydrological, microclimatic, seismological and socio-cultural changes. A few of the anticipated changes that the construction of the Tehri Dam would bring about may be pointed out.

Landslides and erosion

The rapid and frequent fluctuation of water-level of the reservoir—and therefore of water table underground—would produce drastic alteration in the pore-water pressure, and consequently promote and precipitate landslides and related mass movements on extensive scale, particularly in the zone of active faults and thrusts (Figures 2 and 5). The consequence of quickened pace of erosion in the catchments is the larger load of sediments in the rivers and greater accumulation in the reservoirs formed behind dams. While the Tehri Dam authorities take the erosion rate at 13.02 ha-m per 100 sq km per year, the Bhumbla Report[16] computed it at 22.72 ha-m per 100 sq km per year. Thus, the reservoir formed will be filled at rates at least 2 times faster than estimated, giving shorter useful life.

The heavy sedimentation in the reservoir, diminishing their capacity, would often prompt reservoir authorities to panic discharges of flood water, leading to destructive flash floods downstream. There is a reason for this apprehension: In 1978 about 65,000 hapless people in Panjab were rendered homeless when the Govind Sagar water was released in panic without proper warning. In the case of the Tehri Reservoir, there being a provision of surplussing arrangement for discharge of approximately 15,400 cumec (Bhumbla Report[16]), there will be many occasions for panic discharge of this amount of the reservoir water. This will add to the floodwaters of the already swollen rivers of the Ganga system. The maximum recorded flood in the Bhagirathi was 3500 cumec. One can imagine what will happen downstream in the plains when 3500 cumec plus 15,400 cumec water flows down the valley.

Loss of vegetal resources

Loss of production of the agricultural fields that would be submerged and acquired by the Dam Authority would be considerable—20,495 quintals valued Rs 98 lakhs (Paranjpye[15])—and decimation of the inundated 470 ha of forests with their flora (492 species of 99 families) and fauna.

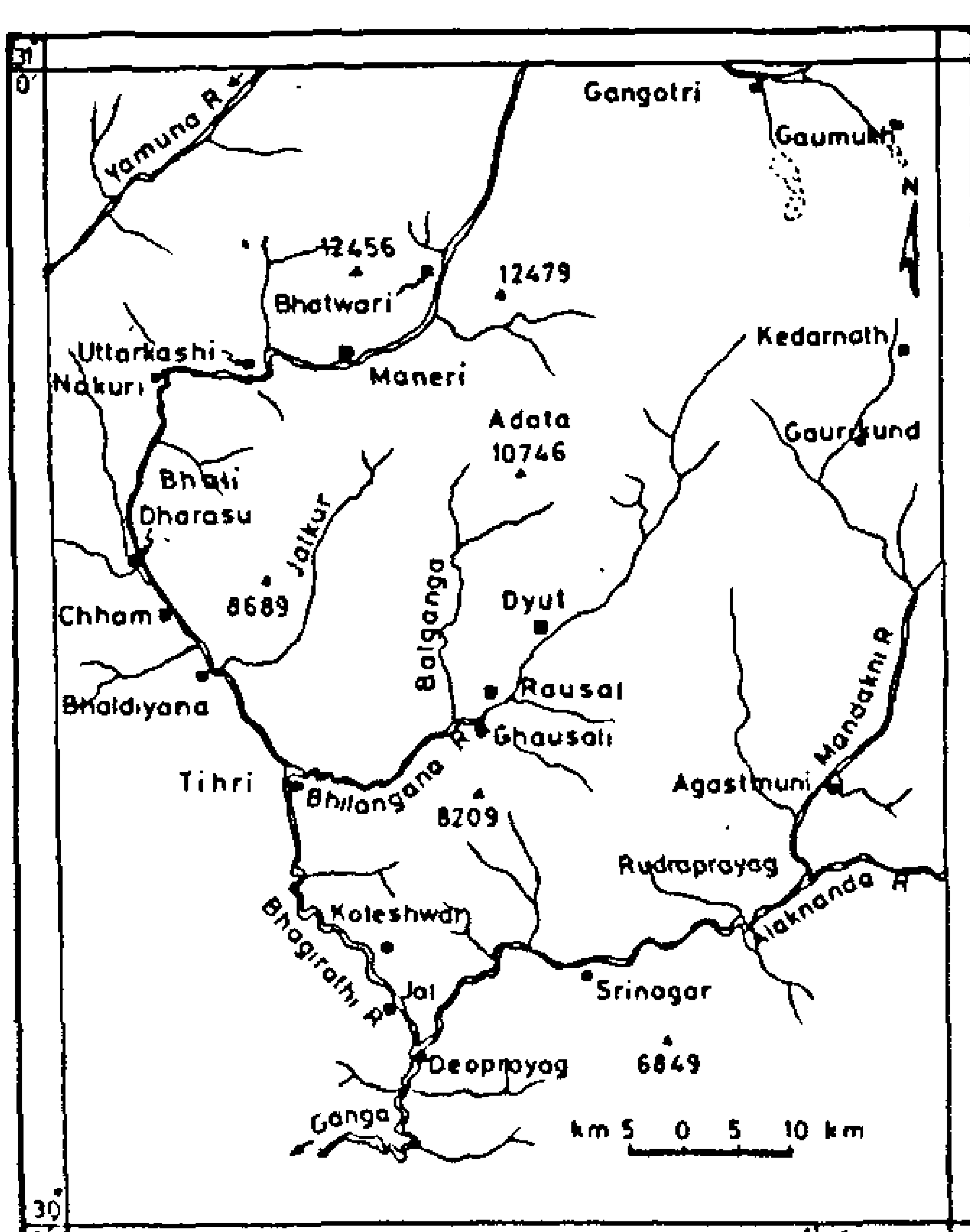

Figure 5. Locations of the important places mentioned in the article

Water-logging and salinization in command area

Round-the-year irrigation available from the network of Middle Ganga Canal, Lower Ganga Canal and Agra Canal in western UP and adjoining region has already created serious problems of water-logging and salinity/alkalinity in many areas. This problem will aggravate over the years. Those who managed to procure water for irrigation, have overdone it in many cases, resulting in getting water more than necessary. This has caused rise of the ground-water close to the surface, retarding plant growth, creating problem for foundation, and converting depression into marshes or pools. Capillary action, likewise, brought to the ground salts and carbonates of calcium and sodium from depth rendering the soil sterile and unfit for cultivation for all times. In more than 2.5 million ha of the chronically flood-afflicted Indo-gangetic plains the soil sickness and resultant loss of productivity will become apparent a decade or two after the farms are brought under intensive irrigation. Nearly 7.1 million ha of land in India have deteriorated in this manner[17].

No benefits for people of Ganga catchment

According to the Bhumbla Report[16], 'despite the Committee's best effort, it could not discover anything in the project proposal which would contribute directly to the economic and social well-being of the people of this region (section 3.9.2). *Has the Tehri Dam not been conceived for the good or for the progress and prosperity of the people of Garhwal also*? Why should the impoverished, weakened, harzard-beaten people of Garhwal be compelled to pay the entire ecological, social and economic costs of the Project? *Can't the nation plan a project which benefits both the people who need power and water, and those who are compelled to sacrifice*

Table 3. Comparison of a big dam with a series of smaller dams (ref. 19).

	Main stream reservoir	Multiple-head water reservoirs
Number of reservoirs	1	34
Drainage area (m^2)	195	190
Flood storage (acre-feet)	52,000	59,100
Surface water for recreation (acres)	1950	2100
Flood pool (acres)	3650	5100
Bottom inundated (acres)	1850	1600
Bottom protected (acres)	3371	8080
Total cost	$ 6,000,000	$1,985,000

their happiness and homes and pay all costs?

In view of these and many distresses that the big dam is likely to create, it will be wiser to go in for alternative plans—less spectacular, larger in number, but without causing radical modification of nature, and not involving large-scale displacement of people.

Alternatives to big dams

Smaller dams

Realizing the damages the construction of big dams like the Tehri Dam infiicts on natural and social environments, and recognizing the great need for storage of water for power generation and irrigation, it would be wiser to go in for many smaller dams (10 to 30 m in height) with a capacity of 50,000 to 10,000,000 cubic metres of water in the reservoirs and each having provision for the generation of 5,000 kW electricity.

Significantly, about a decade ago there were 87,000 small hydel works in China, generating almost a third of its total hydel power—more than half the installed capacity of all the hydroelectric projects in India in 1981.

Lower cost, less damage

A comparison made by Odum[19] of the benefits of a big dam with those of a series of small dams located in tributaries in the same region revealed that the latter not only cost less but bring greater benefits without damaging or impairing the environment, croplands and human habitats, as Table 3 indicates.

Modification of the Tehri project

Even in the Bhagirathi and Bhilangana valleys, there are many suitable (some quite ideal) sites for smaller and moderate dams of great potential. Between Tihri and Devprayag downstream such as at Koteshwar—where a 103.5-m high dam having an installed capacity of 400 MW is proposed—a few moderate to small dams can be constructed. Together these will store enough water to generate large quantity of electricity and provide adequate water for irrigation. A site somewhere between Jal and Shyampur (a little north of Devprayag) can be explored for another moderately high dam, which would prove quite beneficial and a good substitute for the Tehri Dam. The height of the Tehri Dam can be appropriately reduced, even as the Bhilangana–Bhagirathi link tunnel would continue to serve the purpose of generating electricity in quite a large measure.

There are ideal locations for run-of-the river type of dams between Silla-Uppu and Vandrakoti (Bhaldiana–Chham segment) and between Dharasu and Siguni (Dhanari Gad) and Ghansali and Dyut in the Bhilangana valley (Figures 2 and 5). The damming of the Jalkur river joining the Bhagirathi near Bhaldiana—like many other similar streams—would considerably contribute to the power generation and water storage. There is therefore an imperative need for modifying the Bhagirathi Water Development Project, without abandoning the plan of tapping the vast resources of the Bhagirathi Ganga.

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