PANDIT GOVIND BALLABH PANT MEMORIAL LECTURE: VII

Developing a Paradise in Peril

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About Prof. K.S. Valdiya

Prof K.S. Valdiya
Bhatnagar Research Professor at JNCASR, Bangalore
(Born 20 March, 1937 at Kalaw, Burma)

Fellowships

Third World Academy (Trieste)
Indian National Science Academy (Delhi)
Indian Academy of Sciences (Bangalore)
National Science Academy (Allahabad)

Written two monographs, 4 books (one in Hindi), over 85 research papers and 40 popular articles in English and Hindi inn national magazines of wide circulation and repute.

Social Service and Societal Involvement

Deeply and intimately involved in Ecodevelopment through peoples' participation such as development of spring sanctuaries, afforestation in village Panchayat lands, linkages of animal husbandry, horticulture and agriculture, etc. in villages in Kumaun under the aegis of an NGO since 1982. Involved in organizing and promoting Uttarakhand-wide periodic scientific meets of school and college students.

Research Contributions

(i) Pioneering study of cyanobacteria-built stromatolites, initiating a new line of investigation in India, leading ot fixing of age of key horizons and establishment and refinement of stratigraphic order of the sedimentary succession in the Lesser Himalaya.
(ii) Studies related to genesis and chareacterizationof deposits of magnesite and associated soapstone, culminating in their large-scale mining and attendant economic development of eastern Kumaun.
(iii) Comprehensive investigation of palaecurrents and basin analysis demonstrating. for the first time, that it was the north-flowing rivers draining the Aravali terrane in the Peninsular India that deposited sediments in the Himalayan basin-a finding of tremendous importance in reconstructing the palaeogeography of the Indian subcontinent during the Proterozoic Era 9 200 0 to 570 m.y. ago).
(iv) Regional tectonic studies of the intracrustal boundary thrusts and India-Asia junction providing insight into the evolution and development of the Himalaya mountain, particularly with regard to the origin, characteristics, location and neotectnics of the fractured framework of the Lesser Himalayan province, buckling up of the northern edge of the Indian crust, detachment of the cover

fgorm tits basement in the Tettys/Great Himalayan domains, splitting up of the upper crust into duplex structures in zones of bundary thrusts, and the geomorphic, rejuvenation and landscape reshaping due to continuing crustal movements.

(v) Pioneering investigation of the hydrology of mountain speings, their declining discharges and reduced stream flows in relation to environmental degradation and developmental activities.

(vi) Hazard-zone mapping in context of hillside instability ad occurrences of landslides and earthquakes, leading to identification of belts vulnerable to mountain hazards in Uttarakhand.

Awards

Chancellor's medal (1954) at Lucknow University.
S.S. Bhatnagar Prize (1976) of the Council of Scientific and Industrial Research.
L. Rama Rao Gold medal of the Geological Society of India.
National Lectureship (1977-1978) of the University Grants Commission,
P. Pant national environment Fellowship of the Department of Environment (1982-84),
S. K. Mitra Award of the Indian National Sciences Academy (1991),
National Mineral Award of the Ministry of Mines, Government of India (1993) and D.N. Wadia Medal of the Indian National Science Academy (1995)

Membership of Learned Bodies & Expert Committee

Has been/is a member of more than two dozen national committees, expert/councils, governing bodies, including a member of the Science Advisory Committee of the Cabinet of the Prime Minister (1983-85), the sub-committees of the Planning Commission, the Executive Councils of universities, Board of Management of the Geological Survey of India, Councils of two Science Academies, Research Councils of two CSIR National Institutes, etc.

Professional Career

Lecturer at Lucknow University (1957-1969), Reader at Rajasthan University, Udaipur (1969-1970), Senior Scientific Officer (1970-1973), Deputy Director (1973-1976) and Additional Director in the Director's grade (1980) in Wadia Institute of Himalayan Geology; Professor (1976-1995), Dean of Science Faculty (1977-1980) and Vice-Chancellor (1981), Acting Vice-Chancellor (1984, 1992), Kumaun University, Nainital. Professor of Geodynamics at Jawaharlal Nehru Centre for Advanced Research (1995-1997).

Pandit Govind Ballabh Pant Memorial Lecture

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Redefining Development

We set out to make the future of Himalaya safe and secure; what actually we did and /are doing is to make ourselves rich and our posterity deprived and insecure. Undoubtedly, there is growth all-round, but no development. For, the people of the mountain are living in the shadow of fears of ecodisasters and natural hazards. There are very few who discern virtue in conserving the gifts of nature and preserving the integrity of ecosystems. There are some who see beauty In the landscape, but do not care. There are many who look at the mountain assets but with greed in their eyes. And the powerful look away; even as there is utter lack of political will for saving this mountain of tremendous splendor and majesty.

Having no voice in the affairs of planning for development, the mountain people not only feel marginalized but also are quite disillusioned. Time has come for the highlanders to set out their own agenda for environmental security and socio-economic development. Holding the pivotal position in the socio-economic things and closer as they are to both life and nature, the women in the mountains (Figure 1) will have to take up this challenge and assume the responsibility of managing the resources.

A condition has to be attained in which even a common marginal man is able to make more than the subsistence living in his own habitat in the midst of the environment of wholesome ecological health. For a development to become sustainable there has to be, as Pearce (1988) stressed, “the whole process of economic progress in which economies must contribute to the improvement in human welfare”. And this process of development should safeguard, among other things, the ecosystems of the land. There will be no safeguard if the benefits of the development is not shared by all sections of the society, including those living on the edge-the development oustees, the victims of ecodisasters, and the socially deprived.

The material world development cannot be separated from the maintenance of health of natural environment and restoration of degraded or damaged ecosystems. The initiatives for regeneration or restoration of environment cannot but be cross sectoral, entailing involvement of scientists from varied disciplines. Their programmes need to be flexible in approach and compatible with the local tradition and culture.

In my perception there are seven aspects of the development which deserve paramount consideration by the planners, the agencies of development, and by the people whose lives the processes of development will touch and affect (figure 1)

Figure. 1. Marginalized woman in the Himalaya, whose life has been affected by mountain hazards and the deplorable state of the natural environment. Yet she occupies a pivotal position in the socioeconomic scheme of things.

Figure 2. Crustal plate that makes the Indian subcontinent is sliding under the Himalaya at the rate of 18 7 mm per year, along what is known as the Main Boundary Thrust (MBT). The fast-rising Great Himalaya domain is moving up the Main Central Htrust (MCT) that separates the populated Lesser Himalaya terrane from the snowy Great Himalaya domain. The Siwalik in the southern front is separated from the Indo-Gangetic Plains by the Himalayan Frontal Fault (HFF). All these faults are quite active, that is, the mountain blocks are still moving up and down and sideways on them. As the blocks move suddenly, the ground shakes perceptibly. Black circles indicate the epicentres of such seismic events.

(Block diagram after Jackson and Bilham (1994) and the epicentral map from Valdiya, 1997)

1. Quickened Earth Processes and Safety from Natural Hazards

Geodynamically Active Domain

Riven with multiplicity of faults that are quite active and shaken by earthquakes, which are far too frequent in several pockets, the geodynamically, sensitive, youthful Himalaya is going through unrelenting tectonic ferment. The crustal plate that makes the Indian subcontinent is sliding under the Himalayan mass (Figure2) at the rate of 18±7 mm per year (Molnar, 1990). It is the titanic force of compression resulting from collision of India with mainland Asia (Figure 2) that is responsible for this tectonic turmoil of the mountain (Valdiya, 1988). Consequently, the mountain front is rising and frequently shaking.

There are four 200 to 450 km long segments of the mountain arc which were ruptured in the last about one hundred years by earthquakes of magnitude more than 8 – the northern Meghalaya (1897), the Kangra sector in western Himachal (1905), the south-central belt of Nepal (1934), and the northeastern Arunachal (1950). The three unruptured and presently seismically less active parts called “seismic gaps” (Figure 3) seem to be the sites of major earthquakes in the future (Gaur, 1993). For, it is in these segments of the mountain front where the strain is building up progressively, as the Indian plate pushes inexorably northward at the rate of 55 mm/yr. In the central segment that embraces western Nepal, Uttarakhand and western Himachal, no great earthquake has occurred since the 1255 A.D. event near Katmandu. The 1833 A.D. earthquake of magnitude 7.5 to 7.9 happened close to the rupture of 1934 earthquake of magnitude 8.1(Bilham, 1995). Practically the same seismotectonic situation obtains in the Garhwal sector (Chander and Gahalaut, 1995). Thus the seismic gaps remain locked or stuck. It is in these locked parts where the progressively building up strain awaits relaxation. So sizeable is the amount of strain that only an earthquake of magnitude 8 or above is capable of releasing the accumulated energy with attendant major earthquakes.

Environmental Security

Figure 3. Four great slips and attendant great earthquakes of magnitude more than 8 have ruptured the Himalayan front along the plate boundary (Main Boundary Thrust) in the past 100 years, leaving three seismic gaps – locked segments – between them that may be already close to rupturing (From Gaur, 1993)

The severely stressed Himalaya thus deserves extraordinary care when it comes to modifying topography by excavations, putting on loads of water and sediments, changing its groundwater circulation, removing protective cover of forests, etc. obviously, only those programmes of development can be launched which are less extractive and which cause but minimum adverse impact on the ecological balance, which is very delicate.

Earthquakes cannot be prevented from occurring but their impacts can be reduced through timely measures. It is therefore imperative that the environmental security planning be undertaken simultaneous with implementation of development projects. The agenda for the environment management requires. Among other things, identification of zones of areas or hazard. This is done by making hazard-zoning maps (figure 4), which are based on geological, geomorphological, land use, and demographic data and past records of occurrence and through monitoring by geophysical changes taking place. The hazard-zoning maps provide crucial information related to estimation of actual danger (risk) to settlements, systems of communications and lines of essential supplies (Valdiya, 1987).

Figure 4. An exercise in seismic hazard zoning. Bhatia et al. (1992) identify the intersections of faults and fractures characterized by great elevation and steep slopes of the faulted blocks that exhibit conspicuous gravity anomaly as potential sites of earthquakes. In the upper map 21 such spots are the area likely to be hit by seismic events of magnitude (M) equal to or more than 6.5 and in the lower map are shown 36 sites that would be shaken by events of M greater than or equal to 7.0

Once the hazard-zoning maps are available the governments and the threatened communities can prepare hazard-preparedness plans accordingly.

Accelerated Erosion and Landslides

A consequence of tectonic compression of the mountain is the slow and persistent rise of uplift of the terrains. The rate of uplift varies from region to region----- it is 2 to 12 mm/yr in the extreme northwestern Himalaya (Burbank et al., 1996), 5mm/yr in southwestern Garhwal (Rajal etal.,1986), and 2 to 3 mm/yr in southecentral Nepal (Jackson and Bilham, 1984), the uplift of terrain has prompted quickening of erosion rate it is 0.13 mm/yr in dry season to 0/91 to 3.38 mm/yr during rains in central Kumaun (Rawat and Rawat, 1994), 1.73 mm/yr in southcentral Kumaun (Bartarya and Valdiya, 1989), and 1.38 mm/yr in eastern Nepal (Carson, 1985). The present rate of erosion is many times higher than what is was in the immediate geological past.

One of the consequences of accelerated pace of erosion is the voluminous production of sediment, which fills valleys reservoirs. Every one hundred square kilometer area of the catchment of the Bhagirathi upstream of the Tehri dam, for example, is producing 22.72 ha-m of sediments annually (Bhumbla et al., 1990). If the bed load-which is normally taken at 15% of the suspended load-is also taken into account, the amount of accumulated sediments would be quite large. Interestingly, in some rivers in western-central Nepal the bed-load can be 500% to 1000% of the suspended load (Carson, 1985). One can judge the magnitude of erosion and the volume of debris accumulating in reservoirs and floodplains. Along with sediments goes down the nutrient-rich soil, the building block of life. Even slight tampering such as modification of topography for road construction or mining can aggravate soil loss and attendant hazards or land degradation.

Coping With Hazards of Mass-movement

People suffer from the natural hazard not because it happens, but because they come in the way of the natural events occurring swiftly or suddenly (Valdiya, 1987). Of course, man's own activities hasten the natural processes. The programme of coping with the landslide hazard requires identification of areas/belts prone to rock falls, landslides and debris flows (Figure 5) on the basis of geological and geomorphological features, rainfall data, history of past occurrence, and present sings of slope instability. It should be abundantly clear that for the environmental security of an area. The preparation of landslide hazard zoning map is an item of high priority. This requires combined efforts of geologists and geomorphologists.

Figure 5. Identifying zones or areas of slope instability and proness to landslides is an essential prerequisite in the exercise of hazard management.Mehrotra (1994) attempts at hazard-zoning in the Bhagirathi valley in which the Tehri Dam is located.

2. Water Conservation and Spring Sanctuaries

Too Little-Too Much-Water Syndrome

More than a billion people living in Tibet, Pakistan, India and Bangaldesh depend on the water of the Himalayan rivers. Despite abundance of flow (12,00.000 million m^3/year) ------ 4,60,000 million m^3 of the Ganga alone (Table 1) ----- there is scarcity of water practically everywhere in the inhabited Lesser Himalayan domain, Locally the problem has assumed an alarming proportion. More then 40% of the springs in southcentral Kumaun for example, have greatly reduced discharges--- they have either gone dry or become seasonal (Valdiya and Bartarya, 1991).

The situation is as had elsewhere in the Lesser Himalaya. In the snow-fed Seti River (A tributary of the Karnali River) in western Nepal, the difference of volume of water flowing during dry and rainy seasons is 1000 times (Kollmannsperger, 1977). In streams fed by the springs arising in the lesser Himalaya, this difference may be of the order of 3,000 to 60,000 (Kattleman, 1977). The reason is quite obvious. For, less than. 15% of the rainwater is able to percolate down through the ground of trees-less slopes to recharge the springs, more than 85% flowing down as surface runoff to make floods. This too-little-too-much-water syndrome is characteristic of a desert country (Valdiya, 1987). This is further borne out eloquently by the appearance of xerophytes on naked slopes.

Developing Spring Sanctuaries

The need is for augmenting spring discharges. For this purpose sanctuaries for springs in catchments of streams, rivulets and ravines can be developed, by allowing trees, shrubs and grasses to grow freely without interference and tampering (figure 6). This can be ensured by enclosing the catchments with fences or stonewalls in order to prevent access of grazing animals, fodder gatherers and timber seekers. The vegetation in the sanctuaries would grow effortlessly without external input. The genetic resource could also be enhanced. Where the trees have fallen, seedlings. Of appropriate vegetation may be planted and nurtured. The sanctuaries' are located in the areas of ground-water recharge and must be cut with trenches and pits to promote infiltration of rainwater. This will result in augmentation of spring discharges.

This is an area of crucial importance, and environmental institutions should be capable of identifying areas suitable for the development of spring sanctuaries within clusters of villages on the basis of geomorphological layout, geological setting (especially structures). Nature of soil cover, hydrology of streams, etc.

Figure 6. Development of a spring sanctuary entails fencing or stonewalling a part of the catchment of a stream for ensuring unhampered growth of grasses, shrubs and trees, Trenches and pits are dug to induce or promote infiltration of rainwater to recharge springs. The area of recharge is identified on the basis of geological setup.

Water harvesting.

In addition to the development of spring sanctuaries, there should be concerted efforts in every village-or every community of villages-for harvesting rainwater and the storage of water of springs and seepages (Figure 7b). Streams and rivulets can be repeatedly impounded by constructing small and medium,- sized dams (Figure 7a). the aggregate storage would be sufficient to meet the round- the year needs of villages and towns. The distribution of stored water can be left to the Pani/Panchayat constituted of village elders and women.

Figure 7(a) Repeated ponding of streams and rivulets by constructing small dams can accomplish storage of sizeable quantity of water for the use of villages and towns in the vicinity. Conceptual diagram as a suggestion for developing the Thuligad (stream) in Pithoragrah, eastern Kumaun.

(b) Rainwater or streamwater can be safely stored in underground reservoirs and dugout. There will be little evaporation loss, and no pollution by animals and people.

Every household should make provision for storing rainwater failing form roofs. As the people of Marwar in Rajasthan have been doing for centuries. Reading the signs of onset of desertic conditions in the Lesser Himalaya. It would be prudent at this early stage to take all measures to cape with the hazards of water deficiency which is bound opt strike sooner than later.

Melt-Water Storage

The bounty of the Himalaya is also locked in the 1400 km^2 of snow and ice spread over nearly 33,200-km2 area in higher altitudes (Figure 8). There are 15,000 – odd glaciers. The melting of this frozen asset contributes, on the average, about 58% of the water flowing down the Himalaya rivers – 50 to 80% in the northwestern sector and less than 30% in the eastern (Bahadur, 1985). Nearly 49% of the water flowing in the Chenab River, for example, is made up of melt water (Singh et al., 1997). One can have an idea of the importance of the ice pack if one realized that the Gangotri Glacier spread over 200 km^2 is capable of yielding three times the volume of water held in the Govind Sagar behind the Bhakra Dam. Unfortunately, the melting takes place maximally in late summer during rainy seasons when there is already a surfeit of water from the sky. The precious melt water thus goes waste.

This enormous reserve of pure water is now threatened by untimely melting induced by global climate warming, as borne out by receding glaciers and rising snow line. Water-resource development programmes will have to take care of conserving the frozen asset and storing melt water for use when water is needed most, that is during drier seasons. Dams –which can be quite high – in glacier –fed rivers and streams in the snowy Great Himalayan and Tethyan domains will help a great deal in preventing the melt water form going waste. The stored melt-water can be released whenever needed and for the generation of electricity. Located as these dams would be in the wilderness of the ruggedly barren Great Himalayan and Tethys zone where settlements are very sparse o non – existent, the impoundment would not engender the problems that high dams generate in the populated and vegetation-rich Lesser Himalayan terrene.

Figure 8. Vast pack of snow and ice represents the frozen asset. Nearly 58% of discharge in the snow-fed Himalayan rivers in meltwater. A satellite view of the northwestern Himalaya.
(Photo; Courtesy Anshu K. Sinha)

Glaciological and hydrological investigations are thus essential in any programme for the conservation and utilization of water, identification of suitable sites of dams in the glacial valleys need to be taken up as an essential item of the environmental agenda.

3. Conservation Forestry and Tree Cropping

Promotion of Biodiversity

The Himalayan flora are not only diverse in composition with high level (-30%)of endemism, but also have high primary productivity manifest in abundant biomass production value for broad leaf evergreen forests (Sing, 1996). The integrity of the ecosystems of such a forest has to be preserved and protected at all costs.

Not only the weather and altitude but also the slopes of the mountain are key factors in the healthy growth and sustenance of the mountain forest. This implies that gravity has a strong control on their security. The gravity causes slope failures. Therefore any act of man that modifies the slope and causes slope instability resulting in landslides, needs to be moderated. In other words the custodians of forests must see that there are no slope failures and no denudation of the soil mantle providing anchors to trees.

The Forest Department would do well to develop and strengthen a division to take care exclusively of the promotion of biodiversity and protection of the forest ecosystem.

Meeting Growing Demand for Woodstock

Taking into consideration the phenomenally growing demand for Woodstock, and also the fact that the productivity of the dwindling forests is declining (0.7m^3 wood/ha/yr – Khoshoo, 1995) it is imperative to seek alternative sources of fuel and industrial wood. One way in which this can be achieved is to grow plantations of quick=growing trees of requisite species in specifically identified or designated areas. This has to be done in a big way, not by replacing natural forest, but of three-cropping in marginal or degraded lands and in fields found unsuited for agriculture. The aim of optimizing productivity in the long range rather than maximizing productivity in short term is vital and this confers viability and sustainability to traditional system" (Palni, 1996). Significantly, the productivity of tree plantations is greater than that of the natural forests (10 to 20 m^3/yr per tree in plantations compared to 1 to 4 m^3/yr per tree in natural forests according to N. D. Bachkheti in Valdiya, 1987). This is due to absence of inter specific competition in monocultural ecosystem. The environmental scientists are required to delineate onmaps the areas where crops of suitable trees can be raised. Another division of the forestry department – the Division of Tree Farming – would develop and nourish tree plantations and sell the products to the needy, including the industries.

Fighting Forest Fires

What has happened recently in lush rain forests of Indonesia and Brazil should be a lesson for the Indian foresters. Special precaution needs to be taken against fires, which are two, frequent. The pine forests are particularly vulnerable to forest fires, 95% of which are deliberate or due to carelessness. Not only 9000 km^2 area of Uttarakhand is covered with pine forest (Mehta, 1996), the resilient hardy pine is also rapidly encroaching on the realm of oaks, saal and other biologically mature trees. Thus, the pine has become a dominant tree species in the forests of the Lesser Himalaya. The abundance of pine needles in the litter is diminishing the nutrients in the soil as there is leach-out of its caction during decomposition (Schreier et at., 1995). The fires cause incomprehensible damage and loss both to the forests and to the soil, which is deprived of its ability of infiltration of rainwater that recharges springs (Mehta, 1996). It is therefore incumbent on the Forest Department to develop and effective system for coping with fire hazards, including monitoring and remedial measures Formation of an autonomous Division of Forest Fire Fighters may possibly provide security to the forests from conflagrations.

Pasture Development

Realizing that the grazing pressure in the Uttarakhand is 2½ to 4½ times the carrying capacity of forests and appreciating the paramount need for having larger number of cattle as producers of organic manure for the nutrient-starved montane agricultural fields, it is advisable to develop securely fenced pastures for controlled grazing of the community cattle. Undeniably, there is ample scope for genetic improvement of the local breeds (rather than import exotic breeds. The need for the producers of ecologically wholesome animal manure cannot be stressed too much. The adequately fenced pastures should have fodder trees interspersed with grasses. The society expects the environmental scientists to tell how to go about this venture, including increase in the productivity and nutrition value of the fodder plants.

4. Women: The Natural managers of Resources

Ending Drudgery

So small is the per capita land-holding (0.1 ha) in the central Himalaya (Dhar and Gupta, 1992) and so limited the availability of essential resource that menfolk are compelled to migrate out phenomenally for livelihood and sustenance of their tottering economy. There are no opportunities for meaningful/appropriate employment or jobs, and the doors of recruitment to security services are nearly barred to nutrition- deficient men as they have become lately. There is therefore no option for men but to leave their hearths and homes to the care of their women. The women have thus become the principal producers in their subsistence economy. With deplorable decline of forest health the women are now spending nearly 66% more time- approximately 2 to 5 hours per day- for fetching fodder alone (Gurung, 1995). Cash economy – such as production of milk through buffaloes bought with loan money –has only added to the burden of daily chores, without commensurate personal gain or empowerment relating to planning and earning. A woman in the rural world in the mountain has thus become a drudge in her own home.

Unless the various development programmes are geared to be supportive of women's agenda of work, and aim at lessening their drudgery. There will be no development, no progress.

Custodian of Biological diversity

The survival and sustenance of the whole mountain systems depends on the perception, capabilities and enthusiasm of the women. They are not only the keepers of cultural heritage, but also the custodians of biological diversity. Since they are innately inclined towards living in harmony with the nature, and are contented with whatever the nature offers, including forests and water. They therefore have access to these resources and the power to make decisions on resource management.

Target of Training and Women in Forestry

The women should be made the targets of all training - training in management of biomass and water, in animal husbandry, in ecotechnologies of horticulture and agriculture, in planning and budgeting production –related projects, in monitoring and evaluating development programmes, etc. They need to be apprised of the advantages of judicious blend of ecological prudence with traditional technology.

Let women be inducted in the fields of forestry –as range officers, forester, forest guards – and empowered to nurture and protect community forests, tree farms and pastures. Their compassion and benign inputs would convert these plantations into smiling nurseries.

5. Taming Rivers without Bad Impacts

The 12,00,000 million m^3 volume annually flowing down the Himalayan rivers has the potential (Table 1) of generating 28 million kilowatts of electricity; and approximately 2,46,000 million m^3 of water can be utilized of irrigation (Murthy, 1981),. This boundless resource should be tapped wherever possible. However, small decisions taken to meet political expediencies or for realization of immediate objectives without taking into consideration the wider impact of impacts on the environment, society and people's psyche be avoided.

Smaller Dams are Desirable

Bigger dams are known to engender environmental imbalances and enormous societal problems, including the trauma of large-scale uprooting of people (Valdiya, 1992, 1997). Since there is no built-in provision for mitigation or elimination of negative environmental and socioeconomic effects such as restoration of forests, stabilization of slopes and appropriate and adequate relocation of displaced population, and of sharing of benefits by communities living in the command areas and upstream of the dams, it would be better to go in for smaller dams (Figure 7a) which cost less, start giving benefits quite early, bring greater profits, and cause less damage to or impairment of environment, croplands and human habitats (Table 2). This is quite evident form the date (Table 3) collected by the Planning Commission (Singh, 1993).

TABLE 2:
Comparison of a Big Dam with a series of Smaller Dams in a River in the USA
(Odum, 1959)

	Mainstream reservoirs behind a big dam	Multiple-head water reservoirs behind smaller dams
Number of reservoirs	1	34
Drainage are (sq. miles)	195	190
Flood storage (acre-fee)	52,000	59,100
Surface water for Recreation (acres)	1950	2100
Flood, pool (acres0	3650	5100
Bottom inundated and Lost (acres)	1850	1600
Bottom protected (acres)	3371	8080
Total cost	$6,000,000	$1,985,000

TABLE 3:
Expenditure on the Benefits from Major and Minor Irrigation Projects, Planning Commission Statistics
(S.Singh, 1993)

	Quality/Expenditure (million rupees)	Comulative Potential (million hactares)

	Major/Medium	Minor	Major/Medium	Minor
Pre-Plan benefits	-	-	9.70	12.90
First Plan	3,800	760	12.20	14.06
Second Plan	3,800	1,420	14.30	14.79
Third Plan	5,810	3,280	16.60	17.01
Annual Plan 1996-1969	4,340	3,260	18.10	19.00
Fourth Plan 1969-1974	12,370	5,130	20.70	23.50
Fifth Plan 1974-1978	24,420	6,310	24.82	27.30
1978-1979	9,770	2,370	25.86	28.60
Annual Plan1979-1980	10,790	2,600	26.60	30.00
	75,100	12,930	168.88	187.16

Admittedly, the cost of production of electricity is high for small hydel projects – Rs. 15,000 to 8,000 per kilowatt, compared to Rs. 7,000 to 3,000 per KW by large hydel projects (Singh, 1993). However, if one were to think of the real (total) cost of the water resource development which also includes the values of the losses of environment and resources (mineral, forest, agriculture, etc), the cost of damaged land and the enormous expenditure on relocation of uprooted communities, this high cost of electricity generated by small hydel project is more than compensated (Valdiya, 1992, 1997).

As already stated, in the Himadri (Great Himalayan) and Tethyan domains where rivers flow through narrow gorges, higher dams would not only be feasible nut also quite less damaging to the environment and settlements, the latter being very sparse or non-existent.

Cascade Development Hydropower

Chinese provide an inspiring example of tapping stream water in an environmentally very sound and economically rewarding manner. By 1985 they had built about 80,600 small hydropower stations that produced and aggregate amount of 8000 m.W. f electricity of the total of 20,000 kW, hydroelectricity (Zheng Naibo, 1986). These small hydropower projects (Figure 9) entailing cascade development and multipurpose utilization of water of streams and small rivers were planned and developed locally, involving local people. They required less investment, had shorter period of construction and the benefits came quite early. The cascade development tof small rivers fully utilize the river drop, create upper reservoirs for increasing the firm capacity of downstream stations and to operate the cascade stations jointly in order to maintain appropriate water balance between stations (Zheng naibo, 1986). Each project with dam height of 30 to 50 m generates 6 to 12 mW power. The design of small hydropower projects incorporates storage, retention, diversion and interconnection measure, the lower reaches of reservoir serving as the storage basin. There are today thousands of such multipurpose microhydel projects in China.

Figure 9. Tapping a small river in the high mountain for generation of electricity and for storage of water for irrigation and flood moderation under the cascade scheme adopted by the Chinese (Zheng Naibo, 1986)

Environmental Scientists would be required to locate the sites where dams can be constructed with minimum backlashes or adverse effects. Needless to state, geologists, hydrologists, botanists, economists, and social scientists would join hands to carry out exploration and impact- assessment exercises. As a matter of fact, environment impact assessment of major and minor development projects should be the most important preoccupation of the environmental institutions.

Planning new Settlements

Related to the development of microhydel projects is the problem of resettlement of people. In order to stem the alarming tide of exodus of able-bodied, capable and hardworking men, and to accommodate the growing number of people, it is necessary that new settlements be planned and developed. The new township – having clearly spelled out master plans –can be developed in the proximity of hydel projects and around ecofriendly factories and plants (such as milk processing, vegetable-and fruit – preservation medicinal plant extraction), slate and pavingstone quarries, tea gardens, and new academic institutions. The new settlements would not only open up avenues of employment but also provide opportunities for skilled craftsmen and also help ramify trade and commercial ventures.

The locations of new settlements have to be identified on the basis of land capability, freedom form natural hazards, availability of resources (like water, construction material, fuelwood, etc.) and on the likely impact on the society.

6. Utilization of Wealth Stored in Rocks

Mineral Deposits

Reserves of magnesite, dolomite, cement-grade limestone, roofing slate, pavingstone and gypsum are very large and economically very promising. Other minerals like steatite-talc, phosporite, lignite, rock salt, base-metals, uranium-minerals, etc, are substantial, although their mining at present is not always economically profitable or viable (Table 4). Then there are notable deposits of high-cost but low – volume minerals occurring in various parts of the Himalaya. These deposits can be mined in t times of acute need and emergency. Since minerals form the base of al industrial, economic and commercial activities, and are used for the generation of energy that touches all spheres of life of the common man, workable deposits of minerals must be mined. Establishment of slate and pavingstone industry would prove very beneficial and greatly rewarding. However, this is to be done with minimum waste in extraction and rigorous adoption of scientific and systematic methods of mining (figure 10) so that integrity of the environments not violated and its ecological balance is maintained.

TABLE 4
Mineral Wealth of the Himalaya within the Indian Territory
(V.C. Thakur, 1976)

Mineral	Proven Reserves in 1980
Limestone	458 m.t
Dolomite	94 m.t
Magnesite	82.2 m.t
Gypum	66.7 m.t
Graphite	26.7 m.t
Lignite	21.7 m.t
Phosphorite	18.1 m.t
Bauxite	13.6 m.t
Coal	11.6 m.t
Rock Salt	8.0 m.t
Copper-Lead-Zinc	2.2 m.t
Steatite-Talc	1.9 m.t
Flourite	86,000 t
Bentonite	40,000 t
Sulphur	20,000 t
Barytes	13,200 t
Antimony	10,588 t
Borax	5,423 t
Uranium minerals	Appreciable

Mining of quite a few mineral deposits has created environmental problem in a number of areas. This is because of the lack of safeguards against scarification of landscape and triggering of mass-,movement, Consequently, many mining areas have become open wounds and scarred wasteland of barren slopes and eroding soil, Down slope, stream beds have been clogged with debris, and springs and vegetation, buried and smothered by sedimentary wastes.

There was to be a running programme of overall assessment of reserves embracing not only the benefits to be derived from the mining of deposits, but also the magnitude and cost of adverse impacts on water, soil, forest, agriculture, grazing land, etc. There should also be a legislative provision for placing full responsibility of treatment and environmental rehabilitation or restoration of mined areas squarely on mining agencies (Valdiya, 1987). In other words, there should be legal binding on mine-owners to restore the land they damage by resorting to systematic and appropriate methods of disposal of wastes and debris, and regeneration of vegetal cover (figure 10). Stacking and preserving of nutrient-rich topsoil in order to cover back the excavated parts with debris and then put a mantle of this soil over it for growing grasses, shrubs and trees must be made compulsory. Serious attempts should be made to stabilize the slopes, not only during the excavation, but also afterwards, to ensure that the stability is maintained in future also.

Figure 10. It would be quite prudent to extract mineral deposits for meeting the needs of industries, and for building material. However, care has to be taken to stabilize the excavated slopes and also the dumps of debris and wasters during and after mining. The dumps should be covered with nutrient-impregnated soil, so that there is quick regeneration of protective vegetation.
(From Valdiya, 1987)

<u>Tapping Geothermal Energy</u>

There are a large number of springs emitting heated water and steam in fault zones, particularly the Indus-Tsangpo suture in Ladakh, the Main Central Thrust and Main Central Thrust and Main Boundary Thrust (Figure 11). There are 34 hot springs in Ladakh, 34 in Himachal Pradesh. 37 in Kumaun, 7 in Sikkim, and 11 in Arunachal Pradesh. These hot springs have the potential of generating power at the rate varying from 130 milli W/m^2 to 468 milli W/m^2 _ the high value of 300 milli W/m^2 being in the Ladakh belt (Shanker 1989).

The energy from hot springs can be profitable utilized for local development , as is being done in Ladakh. There are two ways in which the geothermal energy can be utilized. The hot waters and superheated steam can be directly conveyed to power plants to operate generating turbines. The hot water and steam can be used to heat buildings and glass housed. The latter fort growing vegetables.

Figure 11. Located in the zones of deep faults that define the tectonic boundaries of the Himalayan terrane, the hotsprings can be profitable tapped for electricity and for heating homes and glass-houses.
(From Valdiya, 1997 based on Shanker (1989)

7. Road Network : Unavoidable Wrecker

Roads are essential for the development of the mountain, despite the serious environmental havocs they create and bring social tribulations and cause economic distresses. The compelling demand for more roads cannot be avoided. Excavations cause interception of groundwater and behead the water table, leading to drastic disruption of groundwater regime. Therefore, special cares have e to be taken in the construction of roads and canals. Where roads are essential, their construction should be undertaken with concurrent measures of slope stabilization (even if these measures escalate the costs manifold). Ecologically vulnerable and geologically unstable zones and areas must be avoided at all cost or bypassed altogether. Only those places need to be brought in the ambit of road networks which are strategically or touristically important and which produce commodities for marketing.

The road construction should be preceded by geotechnical investigations for examining the bearing capacity and shear strength or the roadbed substrate, the stability of the slopes and the conditions of groundwater. On the basis of investigations, alignments are to be suggested and areas of potential instability indicated. Te safe disposal of the debris generated by cutting of slopes is the most important aspect of the road development (Valdiya, 1987). A Road has to be in harmony with the environment and appear as " an integral part of the total landscape rather than an offensive intruder".

Summing up

This is an insider's perspective of the Himalaya --- who regards it as a paradise. I am awed by the majesty of the mountain, and overwhelmed by the tragedy of its people. Forty years of wandering in the mountain fastness and two decades of environmental pursuits have convinced me that intervention of exotic technology and input of external money are not going to make impact on the health of Himalaya's environment and on the trend and pace of socio-economic development of its people. It would be for better to develop and offer working models of ecological and socio-economic development --- of hazard-zoning and risk preparedness exercises, of spring sanctuaries and water-harvesting devices, of tree-cropping farms and ecologically sound pastures, of microhydel projects, of geothermal energy plants, of small scientific pavingstone of slate quarries, and so on. Looking at these pragmatic models the people may feel inspired and be impelled to replicate them in their own ways, using their earthy genius and their limited resources as input.

Since development activities would be aimed for the benefits and well being of the highlanders, they themselves must flex their sinews and strive for getting their goals. There should be no suggestion of bequeathing their Himalaya to only the privileged and the powerful. Let it also belong to those who live on the edge.

What I have stated may appear a uptopain vision. Perhaps it is but then I feel strongly like Mirza Ghalib "If the youths do not try to reach out to the stars, they will end up becoming what we have become". I don't want our children to be like us, stoically, callously unconcerned about the world around us, or plundering the resources, dirtying the waters, fouling the air and defiling the landscape.

I share the sentiments of Tom Knudson who said some years ago on the Sierra Navada mountain. "When my grandchildren come before whoever is in charge at that time and ask where it (the mountain) went, they are going to say there was no one responsible. It disappeared because nobody was responsible". I do not want this to happen to the Himalaya.

The practitioners of research and Ecodevelopment have to see that Himalaya is not put for sale.

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I am grateful to the chairman Governing Body and the Director of the G.B. Pant Institute of Himalayan Environment and Development for bestowing me this honour and giving me an opportunity for ventilating my feelings.

The talented and great son of India Govind Ballabh pant would have had he been alive, exhorted scientists and scholars of all disciplines to strive together in unision - rather than in compartments – to make the Himalaya a paradise once again.

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