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Environmental Hazards in the Himalaya

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Introduction

Himalayas, the youngest mountain chain in the world, gained its present form after three orogenic upheavals, the last one occurring around 30 million years ago. In spite on this time gap it is still tectonically active and is constantly rising.

The Himalaya extends from the bend of Indus river in NW to Brahmaputra in Assam in the East, covering a length of about 2500 km. Transversely Himalaya has been classified into four major mountain ranges—the Siwalik or Outer Himalaya, the Lesser Himalaya, the Great Himalaya and Trans Himalaya. These subdivisions are separated by major geologic faults and thrusts. The Siwaliks and the Lesser Himalayas are separated by the Main Boundary Thrust (MBT), the Lesser and the Great Himalaya by main Central Thrust (MCT) while the Great Himalaya and the Trans Himalaya are separated by Indus Suture Zone. The MCT separating the Great Himalayan ranges from the populated Lesser Himalayan terrain had served as the plane along which the Lesser Himalayan terrain had slid under the Great Himalaya, causing uplift of the latter and splitting, shattering and crushing of the Lesser Himalayan rocks. Along the MBT, the Indian plate along with its Siwalik front is slipping under the Lesser Himalayan crustal plate. s

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The shattered and highly deformed rocks have been tightly folded and repeatedly split by thrust planes into multitudes of rock slabs, some of which are highly mylonitized. Thus the MCT and MBT belts are geodynamically very sensitive and the ecosystems the.y support are in a fragile condition.

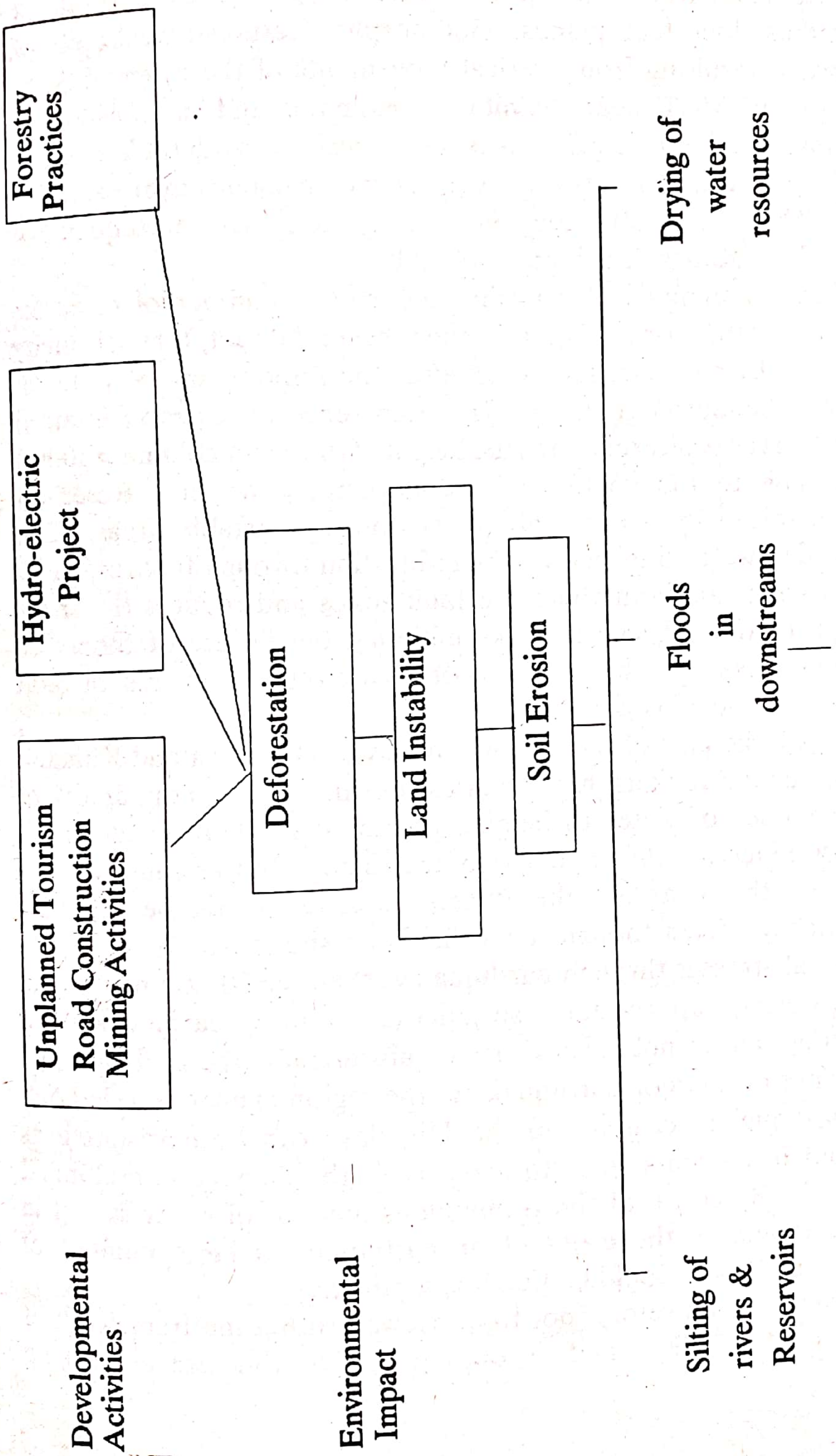
The major rivers of the Indian sub-continent such as Ganges, Indus, Sutluj, Brahmaputra and Kosi originate in the Himalaya Thus Himalaya is the primary source of water in India. These rivers emerge into the plains through the valleys controlled by faults which are seismically active. This high seismicity of the region and the presence of faults, folds and thrusts besides the network of numerous rivers and springs renders the Himalayan ecology fragile.

The Himalaya has been ruthlessly and indiscriminately stripped of its forest cover and deforestation continues. This tantamounts to devastating landslides due to exceptionally heavy rainfall. Besides, large scale construction of dams, roads, tunnels, buildings and other public utilities combined with indiscriminate mining and quarrying has also contributed to the fragility of the Himalayan ecology, creating an environmental imbalance in the region. This imbalance is the progeny of various important, carcinogenic factors, both natural as well as man made. However, a few of them shall be sligthly touched in this pàper.

Seismic Hazard

The distribution of epicenters in the Himalayan region generally follows the trend of the mountain arc. The region has been rocked by several earthquakes including major earthquakes of magnitude 8. The seismicity is quite high in the zones of MBT and MCT. The release of strain energy is not uniform along these thrust zones. It is high along the MCT in Nepal and Himachal Pradesh. In the proximity of the MBT the earthquakes have been of larger magnitude even though their occurrence has been less frequent.

The map prepared by Valdiya, Kaila and Narain (1976), showing the number of earthquakes of magnitude 5 (Richter scale) and higher occurring per year, brings out many areas of high seismicity, such as Srinagar in Kashmir, Spiti valley in Himachal Pradesh, Dharchula-Bajang in the Indo-Nepal border, Arun valley along the Nepal-Darjeeling border etc. The Indo-Nepal border registers largest number of earthquakes per year. There are small pockets of higher microseismicity in the Uttarkashi area (about 40 km



Ecological impacts of developmental activities in the Himalaya (Modified after Gupta, 1983)

NW of the dam site). Generally the clustering of epicenters is seen along transverse features, such faults and the foci lie at a depth of 5 -25 km.

The Himalayan earthquakes have originated as a result of movements along fault planes. Geomorphic features reveal uplift of the Siwalik resulting from vertical movements of the order of 30 to 80 m in the MBT near Nainital in Kumaun and in Lansdowne, Garhwal. The larger earthquakes have caused considerable damage to the life and the land through destructive landslides over extensive areas. The most devastating ones being the Assam earthquake of 1897 and the Kangra earthquake of 1905.

Besides, analysis of seismic data from a number of reservoir sites all over the world has established, beyond doubt, that seismicity is induced by and increases soon after the impounding of water in reservoirs behind large dams. The occurrence of reservoir induced seismicity is critically related to the height of the water column >100m) rather than to the volume of the impounded water. Reservoir induced seismicity occurs only in tectonically unstable areas. The impounded water finds its way by infiltration through fissures, shear zones cavities and joints into the fault zones and reduces the shear strength of the subsurface rocks initiating the failure of otherwise unfailing rocks. So the presence of high stresses and that of fault zones are responsible for RIS.

In a large part of the fault-riven Lesser Himalaya and Kumaun and Darjeeling regions, high stresses prevail. The impoundment of large volumes of water to heights greater than 100m would in all likelihood increase the seismicity of the region. In this context, large dams like the Tehri on the Bhagirathi river should be reviewed scientifically. Even though the Tehri Dam site is free from release of internal stresses through earthquakes, the area 20 km north-west is registering appreciable seismicity. Since earthquakes of magnitude <8 do not release strain substantially, the probability of occurrence of a major earthquake in the region cannot be ruled out. Any earthquake occurring in the Himalaya can be devastating as such and if it occurs close to a reservoir the damage is multiplied manyfold. By virtue of the tremendous amount of water stored in the reservoirs, in the event of an earthquake a large number of downstream towns could be flooded completely.

Dams are therefore, not to be viewed within the framework of technical feasibility and economic gains but are also to be assessed in terms of the environmental changes they produce and the socio-cultural impacts they would have on the communities affected.

Mining Activities

The interaction of processes of mineral exploitation with the environment cause ecological imbalance. Unsystematic and indiscriminate mineral extraction leads to environmental degradation in the form of land misuse and pollution of air and water. The Himalaya, rich in deposits is no exception to this imminent problem. Mining activity including large scale excavation, land subsidence, solid waste disposal, water/air/noise pollution, occupational health and safety hazards are several factors of paramount importance responsible for environmental degradation.

In the Mussoorie hills, on an average three blasts per day per quarry have weakened the jointed and brecciated rocks resulting in acceleration of incidences of mass movements and drying up of springs feeding streams. The discharge of many springs in more than a dozen valleys has diminished and many streams are now quite dry.

Ugly scarcification and drastic reshaping of the landscape and destruction of forests have occurred here as a result of the mining of limestone and dolomite over a stretch of 40 km. When saturated with rain water, the loose material becomes debris flow which descend into the valleys, clogging the channels and spreading over fields. Indiscriminate mining induces landslides and aggravates erosion as witnessed on the Mussoorie Hills, as well in Sikkim where foliated and jointed phyllites are being mined for uraniferrous polymetallic sulphides.

Reclamation of the mined area on a slope more than 14° is rarely successful (Coates, 1981) while in the Mussoorie region the slope is as steep as 30° - 50°. About 14 hectares of forested hillslopes in Kosi valley, Almora distt., and several hundred ha of the Hiunpani forest in the Chandak area elsewhere in Pithoragarh distt. in Kumaun are being crudely mined for soap stone and magnesite. More than 4820 ha of land in Kumaun Himalaya, 11471 ha in the Darjeeling Hills, 438 ha in Himachal Pradesh and 886 ha in J&K have been very seriously affected by mining.

Deeper excavation causes the water table to sink locally, resulting in the drying up of wells and springs of the neighbourhood area. In Mussoorie hills the discharge of the Sahasradhara seepage has gone down due to mining in the area.

Exposure of fresh rocks due to mining initiates weathering with inevitable generation of substances which cause water pollution. Among the minerals involved are pyrite, marcasite, siderite, ankerite which produce sulphuric acids and other soluble salts. All these substances adversely affect flora and fauna.

Phosphorite deposits in Doon Valley are being actively mined. The presence of permeable horizons in the mining area initiate the interaction of mine water with subsurface and open natured drainage water. This introduces phosphoric content in the subsurface and if such mixing is allowed to increase to the level of toxicity, it could become hazardous and unpotable for human consumption. Environmental awareness is yet to establish itself in the form of afforestation and reclamation of mined land in the area.

Deforestation

There is probably no other area of India's environment that has been more viciously attacked and destroyed in the last century than the country forests. The current rate of deforestation is placed well over one million hectares every year. The rate of depletion of forests in the Himalayan ranges, which represent a quarter of India's forest reserves is so immense that this mighty mountain chain could become by the first half of the next century.

In the middle Himalayan belt, which rises to an average height of 3000m, the forest area, originally estimated as being a third of the total area, has been reduced to a mere six to eight per cent. The forests are not regenerating, therefore growing stocks have dwindled and most forests have been totally encroached upon the destroyed. Sunderlal Bahuguna, the champion in the cause of environmental preservation rates the commercial exploitation of forests as the most powerful one. Another factor is the construction of roads without adequate soil conservation measures. Trees are felled and damaged and landslides caused by careless construction have eroded the land so permanently that trees cannot grow there any longer. As a result, many roads have become unstable; the Daksum Chingaon road, for instance, which goes through 70 km of uninhabited area, remains open only for three months in a year. The rest of the time it is blocked either be snow or by landslides.

The northeast of India has one of the largest reserves of subtropical forests in India. The north-east represents 1/7 of the total area under forests in India. Today many tribes still follow the age old method of cultivation called jhum (shifting cultivation). The forests areas are decreasing, human habitations are increasing and the fertility of the soil is diminishing turning the land barren.

With the control of malaria, the forests in the foothills of UP were totally decimated during the 1950s. They have since made way for rich crop lands and today this erstwhile forest region constitutes the most prosperous agricultural area in the state. Forests in UP are now mainly concentrated in the 8 northern mountanous districts together called Uttarakhand. Although about 30% of it is under forest cover, about 1/2 of this forest area is degraded with poor tree density. The optimum density necessary for effective soil and water conservation is now found only in remote valleys of the region. 8% of the total area is facing severe soil erosion and needs to be tackled on a priority basis. The region gives rise to the mighty tributaries of Ganga-Bhagirathi and Alaknanda. Much of the region is prone to landslides and soil erosion.

Stripped of the protective vegetative cover, the Himalayan soils are fast losing their capacity of absorbing rainwater, which largely runs off on the surface, bringing about recurrent damaging floods on the plains. Since little water percolates into the ground, the hill springs are drying up. Over one million hectares of forests are cut every year. Some 0.15 million hectares of forests are lost to development of projects annually.

Landslide Hazard

Landslides and other mass movements are severe environmental hazards in Himalayas. Individual landslides are generally not so spectacular or costly as earthquakes, major floods, volcanoes etc. Yet they are more wide spread, and over the years may cause more loss than any other geological hazard.

The occurrence of landslides is very common in geodynamically sensitive belts in zones and areas repeatedly rocked by earthquakes and affected by other neotectonic activities. The Darjeeling Himalaya, for example, recorded more than 20,000 landslides in a day.

The principal factors that trigger mass-movements are :

(i) Heavy and prolonged rainfall,

(ii) Cutting and deep excavations on slopes, and
(iii) Earthquake shocks.

All these factors operate in the Himalayan region.

Extensive landslides caused by the 1950 earthquake in eastern Arunachal Pradesh and by the 1934 North Bihar earthquake bear testimony to this fact. The vibrations generated by the passages of heavy vehicles create oscillations of different fréquency in the rocks and thus change the stress pattern, reducing shear strength and inducing mass movements.

Most hazards are associated with high speed mudflows and avalanches which acquire speeds as high as 3 to 50 m/s. One great example is the devastating debris flow in the year 1880 on the slopes of Sher-ka-Danda hill in Nainital which travelled 1 km in 30 sec., killed 150 people and swept away 'Victoria Hotel', 'Naina Temple' and other buildings and filled a part of the lake.

The available case records suggest that reactivation of old Himalayan landslides invariably takes place following heavy or prolonged rains. Rainfall in Himalayas is often punctuated by flashes of cloudbursts. A cloudburst lasts for a few minutes to as long as three hours at a time and results in a hazard worse than the combined effect of rainfall for rest of the season. It has been seen that cloudbursts of intensities exceeding 1,000mm in 24 hrs trigger mass movements in any circumstances. A striking example of devastating landslides in eastern Himalayan is provided by Darjeeling floods of 1968. Towards the end of monsoon, vast areas of Sikkim and West Bengal destroyed by some 20,000 landslides killing 33,000 people.

The devastating effect of flowing water coupled with flash floods is dreadful. River slopes are stripped naked, huge landmasses roll down into rivers damming them, and avalanches of mud and water uproot trees on slopes carrying them kilometres away. In Himalayan rivers, broad bed widths alternate with narrow constructed gorges. Occurrence of flash floods, particularly in a narrow river gorge, seems to be one of the much feared causes of some of the major Himalayan landslides.

Accumulation of slipped masses, charge of river silt, massive rocks throttle the narrow river passage building up a reservoir of water that ultimately flushes the obstacles. The resulting drawdown effect triggers slides in the toe region, eventually jeopardising the stability of the hill as a whole. Blockade of river Teesta by massive rocks transported by river current is common.

The narrow constriction of Patal Ganga was choked in July 1970 due to a cloudburst resulting in building up of 60m high reservoir, the bursting of which resulted in floods in Alaknanda and consequently triggering a number of landslides in the immediate vicinity of the river. The flood affected a 400 km stretch and washed away several bridges. The silt carried by the flood water was so enormous that a 100 km stretch of the Upper Ganges canal, some 350 km away from the upper reaches of Alaknanda was blocked. Subsequent desilting operations took very long. During 1978, the region witnessed massive floods again.

Krishnaswamy (1980) reports a number of similar examples of blockades of several Himalayan river in Middle Himalaya of UP, Nepal and Arunachal Pradesh. Landslide dams are made by nature and they usually bring about world's largest catastrophic failures, rarely to be seen in the man-made dams.

Soil Erosion-Sediment Yield

In the next 15 years, an area almost equal to the entire cultivated area of India will be lost to the world if soil erosion continues unabated. Nearly 5-7 million hectares of good agricultural land are being eroded every year all over the world. As with other countries, the future of India, or at least of its ability to feed its people, will depend on the health of its soils. By the turn of this century, the Indian population is expected to cross a billion. Now the pertinent question that looms large is—can we feed such a large population without permanently destroying our lands?

Huge sediment loads are removed from the watersheds as a result of flashy streams emanating from the Himalayan ranges having steep slopes. These sediments are the result of weathering of rocks and are transported by streams, glacier and wind. When there is reduction either in discharge or in slope or in the rate of sediment supply in excess of the sediment transport, the capacity of the stream is unable to transport the material supplied to it and sheds the excess load to exhibit deposition or sedimentation.

The eroding capacity of water varies in proportion to square of the velocity and the ability to transport sediment varies in proportion to the sixth power of its velocity. The extent of erosion and sediment load movement in Bhagirathi, as in other Himalayan rivers is high.

The most glaring example of lake sedimentation today is in the Siwaliks in the Sukhna Lake which was created in 1958 at Chandigarh across Sukhna 'Choc' downstream of the confluence of Kansal and Sukhetri 'Chocs'. Another, equally pertinent examples is that of Alaknanda which in its unforgettable flood of 20 July, 1970, deposited in its channel $9.1 \times 10^6 m^3$ of sediments, removed largely from the landslide ravaged catchment areas of two petty streams.

Annual soil loss from erosion results in increasingly devastating floods and heavy siltation of the enormously expensive dams. The large quantity of soil washed away gets lodged in tanks, reservoirs, streams and river beds, reduces their capacity to hold or convey water and results in heavy, diastrous floods. It is estimated that the bed of Ganga has risen by 1/2 metre in the past few years. However, the long term effect of soil erosion — a general undermining of the ecological firmament that supports our existence is even more sinister.

A survey of some reservoirs revealed that nearly thrice more sediment was flowing into these reservoirs than was estimated at the time when they were built, reducing their life on an average to a third. Reduction in a reservoir capacity to hold back heavy flood water reduces the amount of land it can irrigate.

Conclusion

Strategic planning and implementation of remedial policies is the only answer to reverse the deteriorating trend of Himalayan ecology. As stated earlier, the geologically sensitive areas are vulnerable to landslides and soil erosion. Due to the fragile eco-system, even the slightest disturbance could be hazardous. Landslides and other related movements are natural phenomenon, therefore, cannot be bridled entirely, nonetheless, their frequency and severity can be certainly minimized through appropriate engineering measures.

Some of the vital steps required are afforestation, hazard zone mapping, abandonment of development projects in hazardous areas, restraining of indiscriminate mining and remedial measures for control of landslides.

Veteran environmentalists have been partially successful in creating general awareness among the populace towards the precarious ecology of Himalaya, nonetheless, it is inadequate and greater sensitivity is imperative.

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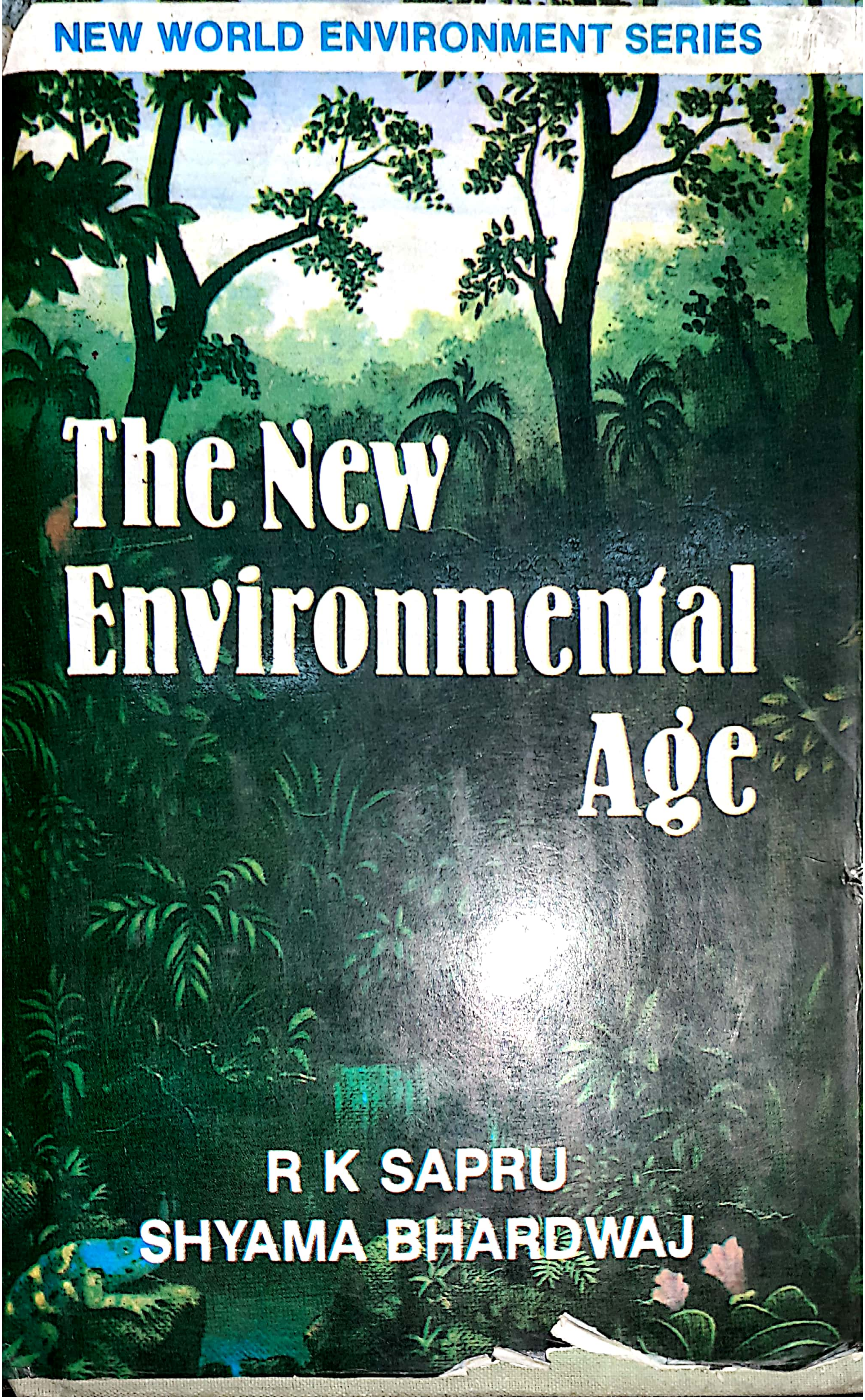
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