

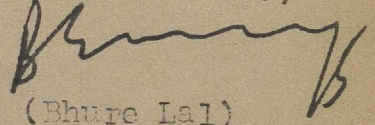
Bhure Lal,  
District State,  
Gandhi.

D.O. No. 5484/III-11 (75-76)  
Dated; Jodhpur; July 20, 1976.

Dear Sir,

Please find enclosed a report about landslide/sinking of Joshimath. You are requested to please forward your comments immediately. The next meeting of committee is scheduled to take place in first week of August 1976. Therefore, kindly send your comments at the earliest to enable the committee to give thoughts to your ideas and incorporate them in the report.

Yours sincerely,



(Bhure Lal)

Dr. Virendra Kumar,  
Botanist,  
Delhi College,  
Ajmeri Gate,  
New-Delhi.

Encls:-As above.

BACGROUND : Joshimath is situated in district Chamoli on the southern bank of river Alaknanda on Rishikosh-Badrinath route. It lies at northing latitude  $30^{\circ} 33'24''$  and easting longitude  $79^{\circ} 36'24''$ . The average height is about 6000 ft. It is a sort of hollow recess sheltered on each side by a circular ridge and to the north of which is a high mountain ridge. Geologically, the area is very unstable resulting in landslides, road breaches and consequent localised subsidence. With the increase in construction activity and population, biotic disturbance has taken place to a significant extent causing frequent landslides. Such occurrences invited the attention of people, who were worried about the future of Joshimath in general and government in particular. As a consequence the government set up a Committee (vide U.O.No.142/23-5/44/76 dated 8.4.1976) under the chairmanship of Commissioner, Garhwal Mandal, to study the problem and to find out the solutions. The Committee consisted of 18 members representing various disciplines - local representatives from concerned departments, Army, I.T.B.P., D.G.B.R., Shri Kedarnath Badrinath Mandir Samiti and local administration. The Committee, to analyse the phenomenon in right prospective acted like an inter-disciplinary body to study, co-ordinate and to suggest measures to implement a multi-aspect plan consisting of water management, soil conservation, forestry, horticulture, building and road construction activity and disposal of night soils, wastes from kitchens and bathrooms.

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The Committee met at Gopeshwar on 3rd May, 1976, under the chairmanship of Sri M.C. Misra - Commissioner, Garhwal Division. The meeting was attended by the representatives of all the concerned technical departments, members nominated by the State Government and local representatives familiar with the problem. Acquainting the members with the problem, the Chairman emphasised that a detailed study of the area should immediately be carried out by experts suggesting short term and long term measures and to translate the magnitude of works to be undertaken in financial terms. This was followed by <sup>a</sup> discussion enumerating the various causes responsible for landslides in Joshimath, a brief discussion of which will follow. It was also decided that the area should jointly be surveyed by a Sub-Committee consisting of representatives from the following departments :-

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TEE.

1. The Directorate of Geology and Mining U.P., Lucknow.
2. P.W.D.
3. Forest Department.
4. Executive Engineer, Irrigation.
5. The Garhwal Jal Sans than.
6. D.G.B.R.
7. I.T.B.P.

The above sub-committee was expected to carry out joint inspections of the area between 10<sup>th</sup> to 15<sup>th</sup> May and submit their findings after discussion.

Keeping in mind the paucity of time, the Chairman laid down following objectives for preliminary survey report :-

1. To find out the cause of landslides and sinking.
2. Short term remedial measures.
3. Long term remedial measures after conducting a detailed study.
4. Financial implications to implement the short term and the long term measures.

Causes of instability :-

Joshinath is not situated on insitu rocks. It situates on weathered, landslided mass of big unsettled boulders in the loose matrix of fine micaceous sandy and clayey material. The rocks are crystalline consisting of schistose gneissic and quartzitic.

Joshinath lies on an ancient landslide. ✓

This landslide zone extends upto big nala near Parsari in the east, in the west upto north-west ridge and nala near Gaukh, in north upto river-bed where some insitu outcrops are noted on the southern bank, while northern bank consists of solid insitu bed rock (Hathi Parbat) and in the south upto and beyond Auli which may extend upto the high mountain ridge forming the water shed.

The actual causes of landslide, the plane of failure and the depth of rock fill in the area are not known. Probable causes can be hillwash, natural angle of repose, location of cultivable area and habitation on an old landslide debris intermixed with Glacial morainic material weathering and undercutting by streams. It may also be due to formation of big fissure plane and movement along this plane. This point is supported by a study of the course of flow of Dhauli Ganga. This river flowing east to west.

takes an abrupt turn to north-west and then to south-west. This complete reverse flow big loop of the river can be due to the daming of the river due to landslides at Tapoban, Reni and Joshimath. Tapoban landslide has been recorded by Heim and Gausser in 1939. Further Dhauligand and Alaknanda Valleys joining at Vishnuprayag are almost in a straight line north-west and south-east. This may be due to a big fissure plane resulting in landslides and as a result altering the course of river forming epigenetic gorges and fossil valleys, and thus Joshimath township might have come up over a fossil valley of Alaknanda river, and Alaknanda might be flowing through an epigenetic gorge and the original valley of the river might have got burried under slide debris on the southern side. The fossil valley in the recent past might have changed the course of river Alaknanda itself. Shri G. Pant's study in his recent report, "Fossil Valleys and Epigenetic Gorges of the Bhagirathi and Alaknanda rivers," lends credence to the above theory. Shri Pant has observed that up stream from the confluence of <sup>DUNLIGAND</sup>(Dhauligand) and Alaknanda, the Alaknanda flows through an epigenetic gorge and the original valley lies burried under slide debris on the southern side.

Landslides might have occured due to natural calamities like earthquake. The fact has been recorded in "Himalayan Gazetteer" by Edwin T. Atkins on Feb 1886 wherein he has recorded that "several of the temples are delapidated having partially over thrown by earthquakes".

quakes." However no remedial measures are effective against such unpredictable acts of nature.

It is clear from the above discussion that Joshimath township and adjoining area situates on an ancient landslide and as such vulnerable to various disturbances. At many places the hill slopes are very steep and the soil has yet to attain the natural angle of repose. Places having no natural angle of repose will be prone to landslides. In the area big boulders and sandy soil are resting in steep slope. During rainy season, surface and sub-surface water erosion takes place culminating in fall of big boulders from hill slope due to presence of cavities. This displacement of boulders from parent hill slope mass takes place because of the presence of the gap between the boulders and the soil. Boulders having this gap are liable to fall in future also. The sinking of the ✓ P.W.D. inspection house can be attributed to this phenomenon. The inspection house is located on a steep slope of more than  $40^{\circ}$ . The whole slope consists of haphazard debris mass and angular to sub angular huge boulders with loose soil as cementing material. During heavy prolonged rains the sub soil water washes out the cementing soil dislodging the boulders and causing sinking. Factors which aggravated the grave situation of P.W.D. Inspection House were the heavy rains in 1971-72 and further steepening of edge by P.W.D. road cuttings. The net result of all these factors was slipping away of a portion of the Inspection House.

Similarly, location of cultivable area on slopes will give rise to landslides because of seepage and soil erosion. Weathering will also have adverse effects because of wear and tear of bare rocks. Under cutting by river currents of Alaknanda and Dhaul Ganga are also playing their part in bringing landslides. The scouring action of these two rivers washes away with it debris and thus the river starts cutting the edges of mountains and inhabited area. The clearing action of swift current takes along with them not only the debris which was providing some protection to the edges but also carry away in their wake sand from the banks and thus cutting keeps on taking place. The scouring action is particularly noticeable at the river bends at south of confluence of Alaknanda with Dhaul Ganga and east of confluence of Alaknanda with Dhaul Ganga. In addition river erosion also takes place which is evidenced by the development of debris slides near Singdhar bridge, and village Khon and some other places along the banks of these rivers. Because of their action the toe support to the hill is eroded and as a result landslides occur. Intensive curing will also have the same effects as it creates unnatural slopes which expedites the boulders to fall and hence should be avoided in and around Joshimath.

Hill washing and percolation of water take place due to rains and melting of snow. This renders the hills bare and water starts percolating inside the hills. The penetrating water in the rocks dislodges them because of washing off of micaceous material.

The boulders get loosened and as a consequence landslides occur. Big cracks are seen in the outer surface of the rocks as is evidenced near Marwari, where a big boulder is said to have been detached from the hill and fallen into the Alakranda in 1970 heavy rains. The percolating water from top of the hill finds an outlet at the bottom. This is established by the fact that water oozing out at the bottom of hills is muddy.

It is commonly felt that the increased construction activity and growing population have contributed to frequent landslides and slips in the area. Heavy construction projects were undertaken in this area after 1962. Indiscriminate felling of trees also took place in the area to make space available for roads and buildings. Heavy construction work without adequate systematic provisions for regulated drainage leads to percolation of water which ultimately causes localised shrinkage and landslides. Various agencies supplying waste water are household waste water, rain, nallah, soak-pits, kachcha drain, unevenness of slopes, presence of cavities, depressions and cracks over hill slopes. The torrential velocity of water flowing down the slope makes the scarcely vegetated slopes bare. The percolating surface water saturates soft soil washing it away and thus creating away cavities in between the boulders. Boulders are without a support now and get detached from the parent mass resulting in slides. Repitition of this process steepens the slope further. As a consequence the hill is devoid of lateral and toe support. The

net outcome is that the stability of the hill is disturbed. An unmattled road at the hill top will also aggravate the problem of water percolation.

With the increase in population, demand for trees for fuel, commercial and fodder purposes has gone up considerably. Felling of trees has been resorted to without having a regard to future implications. Trees are important as they act as mechanical barriers to rains, increase the water conservation capacity and hold the loose debris mass. Increase in grazing and browsing incidents are akin to felling.

Natural forest cover in Joshimath area has been mercilessly destroyed by a number of agencies. The rocky slope is bare and treeless. Joshimath is about 6000 ft. high but the tree line has been pushed up to 8000 ft. Absence of trees results in soil erosion and landslides. The bare peaks are open to attacks of weather. There is nothing to hold the detaching boulders, landslides and slips are the natural outcome. This job could have been excellently performed by trees at mountain tops and slopes.

Blasting has been resolved on a mass<sup>3</sup> scale by DGBR, PWD, ITBP, Army and other agencies in the area for road and building construction purposes. Construction activity has not only disturbed the biotic factors but also the natural hill slopes due to removal of established surface cover. The area contains gneiss rocks which have a quality to fall layer by layer from the main rock. A heavy pressure

is exerted on the rocks at the point of impact by blasting, pushing the boulders downwards. This culminates in landslides as there is no support between boulders. The presumption being that the soil which was existing between two boulders has already been washed away by percolating water. As has already been pointed out that Joshimath is a deposit of sand and stone - it is not the main rock - hence it was not a suitable place for the coming up of a township. Vibrations produced by blasting and heavy traffic will also lead to disequilibrium in natural factors.

Lack of proper drainage facilities also accounts for landslides. The soak-pits which are presently existing are responsible for creating cavities between soil and boulders. It will lead to water seepage and soil erosion.

Remedial Measures:

Taking into consideration the above factors suitable remedial measures should be taken to reduce the quantum of damage and ultimately increase the life span of the township. These measures may be classified into two broad heads viz. preventive and curative.

Preventive measures:- 1. Restriction should be laid on heavy construction work. Construction should only be allowed after examining the load bearing capacity of the soil.

2. For road repairs and other construction purposes it would be advisable not to remove boulders by digging or blasting the hill side. In the landslide

areas stones and boulders should not be removed from the bottom of the hill, as it will result in removing toe support expediting landslide from <sup>top</sup> stones may be procured from the boulders lying at hill tops or away from slip/slide zones. Cutting of trees for supplying the township with timber, firewood and charcoal may be strictly regulated and no tree should be felled in the landslide area. It will be imperative to provide the local people with alternate sources of fuel supply such as electricity, soft coke, cooking gas, kerosene oil etc. Unless suitable alternatives to firewood fodder and charcoal are provided it will not be possible to have an effective check on felling and lopping of trees. This holds equally good for the effective protection of plantations which exists or will be raised in future. State Civil Supply authorities, Ministry of Defence and Ministry of Home may be approached for making adequate arrangements in respect of the above requirements. Fuel and timber arrangements for army, DGBR and Para military forces should be made by respective departments. State Civil Supply authorities will contribute a lot in saving trees in the area by establishing dealers in cooking gas, kerosene etc.

Agriculture on slopes must be avoided. Instead a massive campaign to plant trees and grass should be undertaken to conserve soil and water resources. An extensive programme of tree plantation in reserved forest areas, civil bazaar land, cant area and on

slopes of private land must be undertaken. It should also be borne in mind that trees should be planted in areas where they can grow and survive successfully. The area is suited for trees like Devdar, oak, pine, popular, Robinia, etc. Civil bernaap land is available for this purpose between Marwari bridge and Vishmuprayag extending over an area of 80 hectares. A narrow belt measuring about 50 hectares is also available below Joshimath reserved forest which should also be utilized for extensive tree plantation. Similarly about 50 hectares of land is also available in Dasauli Sixth Reserved Forest. Forest Department should prepare detailed programmes of tree plantations in the above area.

Plantation must also be done on a large scale in cantonment area, areas occupied by Para military forces and on private agricultural land. Ornamental and fruit trees may invite the attention of Army and Para military personnels whereas fruit trees will be the concern of private agriculturists because in due course of time it will be a source of income to them.

The above programmes can be implemented by Forest department during the course of normal activities of the department. A certain number of additional posts will have to be created for plantation and soil conservation purposes. There is only one soil conservation division in the district which is also not very well equipped as far as staff and financial allocations

the period 1976-77 to 1980-81 in the area has been prepared by the department. This programme aims at planting trees in one hundred twenty hectares of Reserved Forest at the rate of 1200 trees per hectare, 180 hectares of civil benaap land at the rate of 1200 trees per hectare and in addition Cantonment and habi-tated areas have also been included where trees will be planted at the rate of 5000 per annum. This programme will cost Rs.  $\frac{9,24,000}{92,400}$  extending over five years. The programme for plantation of trees is both a short term as well as a long term measure. A seed which is plant-ed today will take years to grow up and must be sown immediately without losing time. For its proper growth it must be brought up like a child otherwise it will be a waste. Trees which grow fast should be planted immediately in the most vulnerable pockets. Plantation of trees on all slopes steeper than  $30^{\circ}$  will be a great stabilising factor. The area where tree planta-tion should be undertaken immediately are bare peaks and slopes, military camping ground, Marwari, Belt along Alaknanda, Vishmuprayag and Dhauli Ganga and area Khon.

Engineering Works - the curative measures :

1. Joshinath area is demarcated by permanent tectonic zones, which might be active in present times. Water seepage in the area is profused, therefore to prevent any more landslides in future, it is a must to stop the seepage of open rain water below, hence construction of a pucca drain system is a vital nece-

ssity. Construction of proper and lined drainage as has been done at Nainital where a portion of Mall was sinking, must be undertaken immediately. These drains should be made pucca and should not be allowed to fall in landslide area. The drains should have adequate capacity to tame water during rainy season. Domestic waste water should also be made to flow through pucca drains and finally to fall into the main drains.

2. Roads should be metalled and without scuppers, not permitting any <sup>iv</sup> ingress of water pucca road side drains should also be constructed. The water from these drains should be properly channelised and made to fall in main drain. Roads edge should be kept slightly raised so that crossing over and falling of road side drain is properly planned. The organisations of P.W.D. and D.G.B.R. can play an important role in their respective areas.

✓ 3. Soaking-pits should be closed and sewerage water should flow through sewere line and finally fall into concrete safety tanks which should be well guarded against seepage. The safety tank must not be located in landslide zone. Water from bathroom and kitchen should be treated in the same way. The sewere lines must be properly lined as lining prevents seepage.

4. Water should not be allowed to accumulate in depressions. Drains should be constructed to carry it away to safe areas. In addition searches should be made to locate water inlets which must be closed to avoid percolation of water from surface.

5. All cracks should be filled in with lime, local soil and sand bitumen mixture in the order of lime, local soil and sand bitumen. Sealing of cracks will prevent water from percolating into mountain rock and thus landslides will not occur. This grouting technique should be undertaken by the experts to check cracks and fissure development.

6. Retaining walls and breast wall should be constructed to provide toe and lateral support in affected areas. Work should start on priority basis on either side of Singdhar Narsingh Mandir, P.W.D. Road and along D.G.B.R. road.

7. To avoid scouring by river and slip of <sup>(Loosely)</sup> set terrace material cement blocks should be placed on vulnerable places on the river banks. Toe of the hill slope south of Vishmuprayag and Dhauri Ganga confluence with Alaknanda should be protected from scouring action of the river. The work can be accomplished with the help of cement concrete blocks and wire crates filled with big boulders.

8. Hanging boulders should be provided with support. Similarly support should be provided to boulders lying at the foot hill. This will increase the stability of the boulder lying out the toe and thus help in avoiding landslides.

9. Out of the above engineering measures listed, the following may be classified under short term measures. Treatment of cavities, depression and cracks, closing scuppers in the roads, painting of

roads i.e. Joshinath-Auli Road, raising of road edges and construction of cross and catch water drains in slide zones to discharge water away from affected area etc.

10. The long term measures will include construction of pucca drainage, sewerage, retaining, breast and local walls and putting up of concrete cement blocks to prevent scouring action of river. In addition construction of concrete lined sewerage line and safety tank will also be a time consuming process and action should be initiated in this direction as soon as possible. Army and para-military forces should be actively associated with the programme. Detailed study should be made to chalk out all details of these long term measures by respective departments. An effort should also be made to find out the magnitude of financial implications of implementing these programme-projects.

11. The short term engineering work will cost 7.60 lacks, the break up of which is given as under :-

<u>Project</u>	<u>Executing Department.</u>	<u>Estimated Expenditure (Rs. in lacs)</u>
1. Filling cavity and depression.	P.W.D.	0.70
2. Closing scuppers	P.W.D.	0.69
3. Painting road surface.	P.W.D.	4.30
4. Raising road edges in affected areas.	P.W.D.	1.60
5. Treatment of cracks	P.W.D.	0.20
6. Cross and catch water drains in slide zones	P.W.D.	0.11
	<u>Total:-</u>	<u>7.60</u>

In addition the afforestation programme is likely to cost Rs. ~~92,400/-~~<sup>9,24,000/-</sup> as discussed earlier.

A joint survey by representatives of Irrigation department, L.S.G.E.D., Jal Nigan, Jal Sansthan, Forest department, Hydrel, representatives of army and para-military forces should be conducted to study the problem of water management. Water which is going waste presently can be constructively utilised for the following purposes :-

- i) To check erosion on treeless slopes .
- ii) For irrigation purposes - agriculture and horticulture.
- iii) For generating electricity.
- iv) Water for social forestry as envisaged in the interim report of the National Commission on Agriculture and Social Forestry, Government of India, August 1973.
- v) Supply of hygienic water to army and civil from the reservoir.

It is also recommended that detail studies of landslides should be undertaken for a rational assessment of measures to stabilise and mapping of slide areas. Lasting solution to the problem can be found out by a long time study project of landslides, afforestation and water management. Laboratories and investigation posts consisting of specialists in the above fields should be set up in more susceptible areas.

#### Acknowledgement

The Chairman is thankful to all the members for their co-operation. Further suggestions are solicited for discussion on above findings and incorporation in the report. You are requested to send your comments upto 25.7.76. Date of next meeting will be communicated to you shortly.