A COMPARATIVE STUDY OF WATER DISCHARGE AND SEDIMENT BUDGET OF THEE DISTINCT CATCHMENTS IN RELATION TO INTEGRATED ECODEVELOPMENT IN LESSER HIMALAYA

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Under the present project a comparative study of water discharge and sediment budget of three distinct catchment inrelation to integrated ecodevelopment has been studied in Garhwal-Kumaun adjoining part of the Lesser Himalaya. The study was based on geohydrological condition and watershed conditions understanding the relationship of Lithology, structure, ground water, surface water, rainfall, geomorphology, vegetation and land use. It has been attempted to compare the hydrological responses of the catchments for the development of composite catchment model.

The surface geometry (shape, size, length, order, *etc*.) of the three catchment is almost uniform which are developed on Dudhatoli crystalline zone mainly granite, gneisses and schist. The first catchment (Ghat Gad) was more than 70% cultivated, second catchment (Gun Gad) was moderately cultivated (55%) and moderately forested (45%) while the third catchment (Kolani Gad) was completely forested (95%). A detail geomorphological and geology of the catchments have been described. The study area is characterized by highly folded, faulted and fractured by Kelani formation of rocks experiencing several erosion, recurrent mass movement and recharge of springs. The faults, fractures and joints amidst the rock play an important role in promoting groundwater recharge. The climatic data shows that the study area comes under moderate temperate zone. The average rainfall of the area is 217cm. More than 60% rainfall occurred during the monsoon season.

The total biomass demand is generated by the catchments population and livestock. The cultivated catchment (Ghat Gad) is under heavy population (437/Km^2) and livestock (282/Km^2) pressure. The moderately forested catchment (Gun Gad) is under moderate human (393/Km^2) and livestock pressure (282/Km^2) and forested Kolani Gad is under low pressure (194/Km^2).

Geohydrologically springs and seepage are two forms of surface water discharge. The majority of the springs flow along the faults, fractures and within few meters of the lineaments. The areas with highly sheared and shattered rocks have higher drainage density and stream frequency. Erosion is relatively compound in the areas with average slopes in the range of 15^o to 35^o Landslides, slumping and slope failure have been attributed to slope angle, structure conditions of rocks, geohydrological features, land use conditions, nature of storm and amount of rainfall. The Kelani formation of rocks are prone to mass wasting processes.

Only a small portion of the rainfall infiltrates underground while the remaining flows as surface run off. Four types of aquifers have been recognized in the study area. The springs are classified into 5 types. Seven springs are completely desiccated in the catchments and few others are diminishing their water discharge.

Water discharge and sediment budget of the selected catchments are the main focus of the study. The factors which effect the surface runoff were analyzed. The monthly seasonal and annual water discharge of all the catchments has been estimated from 1995-98. The average monthly water discharge of Ghat Gad, Gun Gad and Kolani Gad were 52.17 l/sec, 70.39 l/sec and 17.36 l/sec respectively. The over all results of the study show that 4 year annual average water discharge of the selected catchment was 626 l/ sec in Ghat Gad (cultivated), 85013 l/sec in Gun Gad (moderately forested and cultivated) and 210.78 l/sec in Kolani Gad (forested) catchment. The rate of discharge was higher in the moderately forested Gun Gad catchment (372.8 l/sec/Km^2/Y), moderate in the cultivated Ghat Gad catchment (305.37 l/sec/km^2/y)and low in the forested Kolani gad catchment (95.27 l/sec/km^2/y. The high discharge rate was recorded in 1995 and very low in 1997 while the highest rainfall year was 1998. More than 65% water discharge was recorded during rainy season from July to September in all the catchments.

Suspended, bed and dissolved load were also estimated among all the catchments. The average monthly suspended sediment of Ghat Gad, Gun Gad and Kolanio Gad were 104.97t, 89.32 t and 24.09 t respectively. More than 75% suspended sediment was recorded during the rainy season in every catchments. The annual average suspended sediment of Ghat Gad. Gun Gad and Kolani Gad

were 316.23, 260.15 and 81.07 tons respectively. The annual bed load of Ghat Gad was 116.39, Gun Gad 72.70 and Kolani Gad 44.45 tons. The annual average dissolved load was estimated 358.38 (Ghat G.) 261.49(Gun G.) and 128.72 (Kolani G.) tons.

Thus 4 years average sediment among all the catchments have been assessed. The maximum sediment rate (514.47 t/km^2/y) was noted in the cultivated catchment (Ghat G.), minimum (254.24 t/km^2 /y) in forested catchment (Kolani G.) and moderate rate (448.28 t/km^2 /Y) was recorded in the moderately forested catchment (Gun G.). Thus the over all sediment transportation rate was estimated 316.82 t/ km^2/y in the study area.

Finally on the basis of total sediment budget the rate of denudation is calculated among all the catchment under different land use types. The 4 years denudation rate of cultivated catchment (Ghat G.) is 0.146 mm/km^2 /y which is highest among all the catchments. The Gun Gad and Kolani Gad denudation rate are 0.074 mm/km^2 /y and 0.049 mm/km^2/y. The comparative study is concluded that cultivated catchment is contributed more sediment load in comparison to moderately forested and forested catchments. The over all results of the study area indicated that the Kelani area of Lesser Himalaya is being lower at the rate of 0.09 mm/km^2/y.

COMPARATIVE GEOENVIRONMENTAL INVESTIGATION IN DEWALGARHGAD AND BACHCHANGAD CATCTHMENTS, GARHWAL HIMALAYA , UTTARANCHAL

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The Dewalgarhgad and Bachchangad form a typical lesser Himalayan catchments situated on north facing slope of Alaknands river and fall in the jurisdiction of Pauri and Rudraprayag districts of Uttaranchal State.

Dewalgarh stream flows in S-N direction whereas Bachchangad has SE-NW trend. The area exhibits phreatic to subphreatic climate zones, with four distinct seasons *viz*; summer, rainy, autumn and winter. The Dewalgarhgad catchment shows immature topography, consequently favoring a more run-off. The upper reaches of Bachchangad catchment indicated a mature topography while lower part exhibits a youthful stage of landform development.

Geologically, the area is constituted by two different group of rocks *i.e.* Garhwal and Dudatoli formations containing quartzite, phyllite, carbonates and metabasies separated by a tectonic plane called Srinagar thrust, which crosses both the catchments. Besides, Srinager thrust, the other structures include a major syncline *i.e.* Dudatoli syncline, a large number of minor folds and faults, major and minor joints, criss cross fracture and cracks and volcanic plugs and intrusions. All these have influenced hydrological regime of the area.

Bachchangad catchment has 44.68% area under forest cover while Dewalgarh contains 34.6% area in this category. Therefore, most springs of former show comparatively steady and sustainable discharge. Oak forests are being replaced by pine forests, which has adversely affected soil fertility, soil erosion and recharge- storage- discharge characteristics.

Apart from anthropogenic activities, natural disasters such as seismic tremors, neotectonic activity, floods and landslides *etc*. are thought to be responsible for diminishing discharge or disappearance of most of the springs during last 50 years.

Most of the inorganic substances, in general are found upped permissible limit as per WHO standard, Bacterial percentage is considerably high in water of all the springs, therefore treatment before use is essential, Regular cleaning of spring site is necessary, Laying of sewage lines around spring and in recharge zone should not be allowed to avoid any contamination.

Since, springs are main source of water, their conservation and substitution should be encouraged. Development of spring sanctuary following biotechnological management measures, afforestation in recharge zone, dumping of debris over the hill slopes, building constriction *etc*.) and total ban on grazing would certainly restore the discharge from the springs. Rainwater harvesting would be better substitute of disappearing springs. Extension, R&D and environmental awareness programs should be launched through NGOs and Universities/ Institutes, so as to obtain better results.

SUSTAINED UTILIZATION OF GARHWAL HIMALAYAN TIVULETS FOR ELECTRICITY GENERATION BY MODIFYING *GHARATS*

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The major aim of this project was to generate electricity by modifying traditional Gharats run by perennial water resources (rivulets) in District- Rudraprayag/ Chamoli at village level.

Water survey of different rivulets in the study area Distt.- Rudraprayag has been carried out. Most of them have been found potentially rich to run the modified Gharats for electricity generation. Some of the identified rivulets are *Byungad, Kusin Gaad (Bhiri), Kakra Gaad, Madhyan Gaad and Damar Gaad, etc.*

Gharats are traditionally run by open channel type system (pannal). Their efficiency can be improved by a pen stock type pipe which ensures security and an increase in the potential of an available water mass. The efficiency of a traditional, *Gharat,* a vertical axis system, if replaced by a horizontal axis system, could be increased by using ball bearings at the both ends of the axle of the turbine and the number of r.p.m. can be matched by usual pulley and belt conversion system, which can be managed as a well balanced system. Thus the functioning becomes more smooth and durable. By cascading the modified *Gharats* on a single rivulet, maximum utilization of available water and gradient can be achieved.

In the present study a *Gharat* has been modified by using a pen stock jet system. The pen stock height was 20m and jet diameter was 0.06 m. The jet was directed on a Pelton wheel style indigenous turbine attached with an alternator of 10 KW whose r.p.m. was matched by the coupling belt- pulley arrangement. As a thumb rule it has been established that for a 0.06m diameter jet and a matching turbine- alternator system, 1 KW electricity is achieved for every 2m penstock height. The progress report of the research activities carried out has been sent to the funding agency from time to time.

A low cost, easily manageable, economically viable and sustainable and eco- friendly perennial system has been designed and installed, at village level, to generate electricity- an answer to the power problem in the hilly regions. If motivated, the village people of the region can establish small systems for their use at family and/ or village level.

Few local people *(Kedar Ghati Prakritic sansadhan Vikas Sansthan, Byungad,* a registered Society) have been trained to maintain the unit at village Panchayat level. After the expiry of the duration of the project the *Kedar Ghati Sansadhan Vikas Sansthan* look after and maintain the unit for the benefit of the local people.

There are two villages*, Byungad* and *Nawara,* where approximately 50 families are scattered with in 1 Km range from the project site, Electrification of these villages can be done easily At present there are no funds available for purchasing conductors, poles, wires, *etc*. for connecting the unit to the villages. Though the villagers are eager to get connected with the unit for electricity supply. The electricity generated can be useful for cold storage of fruits, potatoes, *etc*; milk storage, wood work, grinding grains, *etc*, in the area. And this is a typical situation of most of the villages of the region

The developed prototype has been just installed and is working faithfully under the thumbrule that for 20m pen stock height and o.06 m jet diameter and presently designed turbine- alternator system, it gives 10KW electricity. For its feasibility for a longer time, in winter and summer, in rainy season when the content of silt and mud in the water varies, the system has to be tested thoroughly under the naturally varying conditions. By studying the dependence of the developed system under these fluctuating and varying parameters the safety measures will be included for a technical extension of the designed system and the related observations. Which will be communicated to the Funding Agency in due course of time. The funding agency is further requested to extend funding of such type of developmental activities in hills in future

A STUDY ON MASS WASTING AND OTHER SLOPE PROCESSES, A STEP TOWARDS REDUCING ENVIRONMENTAL HAZARDS IN A PART OF GARHWAL HIMALAYA

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On the hill slopes serious mass wasting takes place through various mass movements such as, erosion, rock and debris fall, debris and mudflow, slump, slips and landslides. Almost all of these processes create and continue with the help of water either in form of ground water or surface water. Drainage network and the watershed basins therefore act as an important component of all these processes. However, it is to be noticed that such phenomena are not spread in all the slopes. In spit of the dense drainage network some slopes are not suffered with such processes. Obviously there are various inherent and external factors those act together to make the slope susceptible to such activities. The inherent geological and geo-structural setup also play a dominant role in structuring the drainage network e.g. lithology, tectonic and neo tectonic activities and related structures such as faults, thrusts, fractures, joints, *etc*. However, further development of the network and the associated mass wasting processes depend on various other factors like rainfall, anthropogenic activities and others. Under this project the role of drainage and its watershed basins along with other factors in mass wasting activities has been studied in an area between Narendra Nagar- Rishikesh - Sivapuri in Garhwal Himalaya.

In the study area four orders of streams were mainly captured namely first, second, third and fourth orders. There are 1063 first order of streams 256 of second order, 63 of third order and 9 of fourth orders. The basin watersheds formed according to the number of the streams and their orders. Only 98 watershed basins were identified, out of which the third orders of basins were found 34 numbers.

In this study main emphasis is given on third order basins which are most significant because they contain all first, second and third order streams and are well distributed and good in numbers. The formation of the basin watersheds is followed by measurements of the morphometric properties. Before going for measurements the variable required to be considered for the relationships are selected. Such as Number of streams of order (2,3&4), Total number of streams within basin each basin, Bifurcation ratio, Total length of stream of each order, Mean length of stream of each order, Total stream length within basin of each order, Stream length ratio, Basin Geometry, Area of basin (sq. km), Length of basin (sq. km), Width of basin (sq. km), Basin perimeter, Basin circularity, Basin elongation, Drainage Density, Constant of channel maintenance, Stream frequency and texture ratio.

The measurements of morphometric variable of each of the third order basin was carried out along with the statistical analysis such as product moment correlation coefficient and the linear regression analysis. The results on this analysis are correlated with the mass movements in the region.

ESTABLISHMENT OF RAKSHAVAN AT DHANTOLI (MANA) IN BADRINATH DHAM

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An innovative programme under the name of "*Rakshavan* [a sequel to Badrivan (the ancient sacred forest of Badrinath)] *Establishment Programme"* was launched at Dhantoli in Badrinath, Chamoli Garhwal (U.P.) from 1st April 1998 to 31st March 2000. During the two years' tenure of the project, environmental awareness, especially for plantation of trees in Badrinath valley by organizing tree plantation ceremonies and group discussions, was created and promoted among the local people, pilgrims, army personnel (including Garhwal Scouts) and villagers of the eight adjacent villages of Badrinath (namely, Bamani, Indradhara, Gajkoti, Bhrigudhara, Naigani, Dhantroli, Mana and Patia) *etc*. For the establishment of Rakshavan, a plantation site (1560m in running length; approximately 10 ha degraded area) was developed at Dhantoli (Mana) in Badrinath valley (10,280 ft. amsl) and fenced by barbed wires. Almost 16,697 well-established and hardened saplings of various high altitude trees/shrubs (as obtained, free of cost, from Hanumanchatti nursery of GBPIHED) were planted at Rakshavan project site during the tenure of the project. Out of these 16,697 saplings, only 15,299 saplings of eleven high altitude trees/shrubs were found to have survived at the project site up to the date of completion of the project (*i.e.*, 31st March 2000). In addition to the above, a nursery of high altitude trees/shrubs was also established within the plantation site at Dhantoli (Mana) in Badrinath valley at an elevation of 10,280 ft. amsl after ensuring nursery development activities. During the tenure of the project, the nursery was enriched by 1,26,269 seedlings/cuttings of various high altitude trees/shrubs. Out of these, only 86,379 seedlings/cuttings of twenty six high altitude trees/shrubs were found to have survived at the nursery up + to the date of completion of the project.

During the two years' tenure of the project, seeds of twenty five (25) promising high altitude trees/shrubs were also collected from time to time and sown subsequently in the nursery at Dhantoli (Mana) in Badrinath valley. Observations on seed germination potential of 21 trees/shrubs were also recorded under natural condition. Furthermore, meteorological data on minimum-maximum air temperature, solar radiation, relative humidity, wind velocity and soil temperature were recorded at Rakshavan plantation site in Badrinath valley. In addition to the above, maintenance and care of plants in the nursery and plantation site were also carried out on basis during the tenure of the project.

The overall IERP project work carried out by the Garhwal Scouts has resulted in the survival of 15,299 trees/shrubs of eleven high altitude species at Dhantoli project site (which has now constituted Rakshavan in Badrinath valley) and also in the survival of 86,379 seedlings/cuttings of twenty six high altitude trees/shrubs at the nursery (which will now be used by the Army for the purpose of plantation in other high altitude degraded areas in addition to the further plantation at Rakshavan project site). The Rakshavan model (as developed by the Scouts under the project) has been considered an inspiring model especially for reforestation of degraded lands and biodiversity conservation not only in other parts of Himalaya but also elsewhere throughout the world where high altitude areas are degraded and the environmental has been severely threatened.

BIOLOGICAL NITROGEN FIXATION FOR PRODUCTIVITY OF SOIL AND CROP: CHARACTERISATION OF EFFICIENT *RHIZOBIUM* SPECIES ISSOLATED FROM WILD LEGUMINOUS WEEDS OF NE HILLS

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As many as 63 Leguminous weeds from seven north-eastern states were collected and subjected to morphological, biochemical and genetical characterization of strains isolated from them.

Rhizobium strains isolated were found from low soil pH 4.00. All the strains were found to be "fast growing" and acid producer. The strains were subjected to cross-inoculating groups. Excepting one strain, all other failed to cross-inoculated Group-I (e.g. *pisum sativum* and *Vicia faba* var. *villosa*), Group II (e.g. *Phaseolus vulgaris* and *P mungo),* Group III (e.g. *Trifolium* sp.) and Group IV (e.g. *Trigonella* sp.).

Difference in resistance and inhibition capacity of the isolated strains to different antibiotics were observed. Determination of Plasmid DNA of an efficient strain was done and approximately molecular weights was found to be 40.7 kbp.

It is suggested that further modification in cross-inoculation test and collection of leguminous weeds from their endemic habitat should be done. List of 47 Leguminous weeds have been complied and listed with their place of endemic in the North East Region.

Highlights of the findings achieved in the Project

Following findings was achieved in the project :

(a) A few *Rhizobium* species isolated were from low soil pH e.g. 4.00. Most of them are acid producer.

(b) Most of the *Rhizobium* species isolated were :fast growing" (grows within 20 hours).

(c) Technique for determining Plasmid DNA of *Rhizobium* strain was standardized. Birboin and Dolym (1979) method was found more suitable.

(d) Molecular weight of Plasmid DNA of only efficient strain detected from cross-innoculation test, was found to be nearly 40.7 kbp.

(e) An easy procedure was worked out for preserving the collected root nodules for a longer period at a very low cost.

(f) The strains differed in resistance and inhibition capacity to different antibiotics.

(g) It was thought that the *Rhizobium* strains of Leguminous weeds have lost their potentiality for infecting the cross-inoculating groups, due to shift from their original place of endemic and change of environment as well as other edaphic factors. List 47 Leguminous weeds have been complied and tabulated in Table 4 (Page 31 to 35) with their place of endemic in the seven N.E. states.

DST's Workshop on "Bio-Geo Database for the generation of Sustainable Development plan for Uttaranchal"

A three-day workshop was organised at G.B. Pant Institute of Himalayan Environment and Development, Almora during 4-6 September 2001 by Natural Resources Data Management System (NRDMS) of Department of Science & Technology (DST). The workshop was planned to address the issues pertaining to the development of a coordinated programme such as identification of study area, user requirements, thematic sectors, specific research groups *vis-à-vis* identified sectors, inter-departmental coordination and implementation mechanisms with the state government. About 60 representatives from various organisations, institutions, universities, and NGOs actively participated in the workshop.

Shri B.S. Rawat, Hon'ble Minister of State for Science and Technology, Government of India inaugurated the workshop by giving the presidential address. Five technical sessions *viz*. Site selection and data requirements assessment, Data availability position, Presentation of technical proposals, Consolidation of proposed projects, and Review of the integrated programme were oragnised to workout the strategy for the development of an integrated programme aiming to generate information and analytical tools for making the sustainable developmental plans by the decision makers of Uttaranchal.