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Evaluating the contribution of avalanching to the mass balance of Himalayan glaciers

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ABSTRACT. Avalanching is a prominent source of accumulation on glaciers that have high and steep valley-walls surrounding their accumulation zones. These glaciers are typically characterised by an extensive supraglacial debris cover and a low accumulation area ratio. Despite an abundance of such glaciers in the rugged landscapes of the High Himalaya, attempts to quantify the net avalanche contribution to mass balance and its long-term variation are almost missing. We first discuss diagnostic criteria to identify strongly avalanche-fed glaciers. Second, we develop an approximate method to quantify the magnitude of the avalanche accumulation exploiting its expected control on the dynamics of these glaciers. The procedure is based on a simplified flowline model description of the glacier concerned and utilises the known glaciological mass-balance, velocity and surface-elevation profiles of the glacier. We apply the method to three Himalayan glaciers and show that the data on the recent dynamics of these glaciers are consistent with a dominant contribution of avalanches to the total accumulation. As a control experiment, we also simulate another Himalayan glacier where no significant avalanche contribution is expected, and reproduce the recent changes in that glacier without any additional avalanche contribution.

Keywords: Avalanches, debris-covered glaciers, glacier mass balance, glacier modelling

INTRODUCTION

It is rather well established that avalanches are a significant contributor to the net accumulation of ice on many glaciers in the high-relief Himalayan mountain range (Benn and Lehmkuhl, 2000; Benn and others, 2003; Scherler and others, 2011a; Nagai and others, 2014). However, the question of quantifying the avalanche accumulation and its long-term variability remains largely unexplored in the literature. If a broader understanding of the mass-balance processes in the Himalaya as well as in other glacierised regions in the world were to be achieved, a technique to address this issue must be developed. Such a development would be of help, on one hand to get a clearer picture of the recent climatic response of the Himalayan glaciers (Cogley, 2011; Scherler and others, 2011b; Kääb and others, 2012; Gardelle and others, 2013) and on the other hand to predict their future evolution reliably (Marzeion and others, 2012; Immerzeel and others, 2013).

A stochastic and highly localised accumulation of snow and ice on the inaccessible and often hazardous avalanche cones along the valley walls (Fig. 1) makes it difficult to directly measure the avalanche contribution using standard glaciological mass-balance techniques. However, neglecting this contribution would lead to a significant bias in the measurement of the mass balance. Therefore, standard manuals for mass-balance measurement advise against choosing glaciers where a strong avalanche activity is expected (Kaser and others, 2003). This is a serious limitation as far as Himalayan glaciers are concerned, where avalanche contributions often play a dominant role. For example, Scherler and others (2011a) have demonstrated that in several regions of the Himalaya the fraction of strongly avalanche-fed glaciers is quite significant. They analyse three characteristic indicators of a strong avalanche activity: (1) high slopes in the ice-catchment area, (2) a high percentage of ice-free catchment above the snowline, and (3) low accumulation area ratio (AAR). Their data from a set of 287 glaciers in the Himalaya and Karakoram show that these characteristics are indeed correlated. In particular, almost all the glaciers with a AAR <0.2 have a very high percentage of ice-free catchment area above the snowline and, thus, are likely to be predominantly avalanche-fed ones. Such glaciers constitute 18% of the all the glaciers studied by them in the Western and South-Central Himalaya. This gives a ball-park estimate that in these regions of the Himalaya: it is likely that a significant percentage of the glaciers (about one in five) are strongly avalanche fed. Several models have been developed to estimate the snow redistribution due to gravitational processes, given the snowfall data and the topography (Gruber, 2007; Bernhardt and Schulz, 2010). However, a serious lack of reliable snowfall data in the glacierised high Himalaya (Viste and Sorteberg, 2015) limits the applicability of such tools in estimating avalanche contribution to the mass balance of a specific glacier. Moreover the ice-avalanche contribution to the mass balance of reconstituted glaciers (Benn and others, 2003) would not be captured by these methods. This necessitates an alternate indirect method for estimation of avalanche derived accumulation, possibly making use of available glaciological data. We hypothesise that the significant avalanche accumulation exerts dominant control on the observed pattern of shrinkage in these Himalayan glaciers.

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Stability Analysis of Rock Slopes along Gangadarshan, Pauri, Garhwal, Uttarakhand

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ABSTRACT

The rock mass rating (RMR) and slope mass rating (SMR) has been carried out to classify the slope in terms of slope instability. To understand the RMR and SMR various geostructural, geomorphologic and hydrological parameters of the slopes were measured and analyzed. 32 rock slopes/rock cum debris slopes were identified in the study area. The present RMR and SMR study is an outcome of extensive field study along a stretch of about 10 km on road leading from Srinagar to Pauriarea along Alaknanda valley. The technique followed incorporates the relation between discontinuities and slope along with rock mass rating (RMR) and slope mass rating (SMR). The analysis of the 32 studied slopes shows that in the Gangadarshan area out of six rock slope facets, two falls in class II (stable) and four in class IV (unstable). It is significant to note that the slope facets coming under class IV are comprised of active landslide portions. While the slopes under class II show minor failure or old landslide debris.

INTRODUCTION

The feasibility and preliminary design stage of any engineering project, slope mass its stress and hydrologic characteristics, the use of a rock mass and slope mass classification scheme are of considerable benefit. This may involve using the classification scheme as a check-list to ensure that all relevant information has been considered. On the other hand of the spectrum, one or more rockmass classification schemes can be used to build up a picture of the composition and characteristics of a rock mass to provide initial estimates of support requirements, and to provide estimates of the strength and deformation properties of the rock mass.

In the Alaknanda basin, evidences pertaining to the landslide damming of the rivers are limited to the higher Himalayan ranges around the Main Central Thrust (MCT). The zone of the MCT is not only seismically active, but also characterised by intensive rainfall zone. Away from the MCT towards the south, there is no evidence for river damming in the geological past.

Rock mechanics is considered as a modern engineering discipline, however, as early as 1773; Coulomb, included results of tests on rocks. Karl Terzaghi (1936) addressed first international conference on soil mechanics and foundation engineering. Terzaghi (1936) and Terzaghi and Voight (1979), stated that "the catastrophic descent of slopes of the deepest cut of Panama canal issued a warning that we were overstepping the limits of our ability to predict the consequences of our action". During 1920 to 1958, Josef Stini published more than three hundred papers and was probably the first to emphasize the importance of structural discontinuities on the engineering behaviour of rock masses. During the early part of twentieth century, scientists and engineers from different disciplines did some significant work on behaviour of rocks. King (1912), Griggs (1936), Ide (1936), Terzaghi (1945), Ramamurthy (2004) and Naithani (2007), worked on the failure of rock materials.

Slope instability is the condition which gives rise to slope movements (Crozier, 1989). Instability of slope represents the condition in which the limit of stability reduces to zero. The slope stability assessment was carried out in the Alaknanda and Bhagirathi valley by some workers (Mehrotra et al. 1994, Nainwal and Prasad, 2001, Chakraborty and Anbalagan, 2008).

The basic outcome of the study is to estimate the rock mass rating and slope mass rating of the various rock slopes present in the study area. Based on the RMR, calculation of slope mass rating, the various slopes present in the study area has been categorised of slope in terms of instability.

STUDY AREA

Administratively, the study area falls in the Pauri district of Uttarakhand Himalaya.

It also falls in lesser Himalayan region along Srinagar-Pauri (Alaknanada valley) Garhwal Himalaya, Uttarakhand (Fig.1). The investigated area is approachable from Rishikesh and Srinagar by road (NH-119). The study area is bounded by 30.2112°N, 78.7654°E to 30.2099°N, 78.7477°E , covering a stretch of about 10 km length of road section. Survey of India toposheet number 53 J/15 and 53 J/16 on a scale of 1: 50,000 were used to prepare base map.

Geological Setup

The study area lies on the national highway-119. Geologically, Chandpur phyllite region and specifically in the locality of the Gangadarshan which is virgin area according to the RMR and SMR study point of view. The study of the RMR and SMR of the area could help in figuring out the stability categorization of the area.

METHODS

Rock Mass Rating (RMR) Study

The geo-mechanical properties of slopes were evaluated by rock mass rating (RMR) system following I.S. code 13365 Part 3 (1997). The RMR is determined by adding the rating values of the following parameters: (i) uni-axial compressive strength of the rock, (ii) rock quality designation (RQD), (iii) spacing of discontinuities, (iv) condition of discontinuities and (v) groundwater condition.

The quantitative classification of rock mass provides not only a basis for understanding characteristics of the different groups of rock

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ORIGINAL ARTICLE

Modelling of Recent Erosion Rates in a Lake Catchment in the North-Western Siwalik Himalayas

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Abstract Investigations have been carried out on Sukhna Lake catchment in the north-western Siwalik Hills in the Himalayas, to estimate recent erosion rates and to assess the impact of conservation measures on the erosion rate. The RUSLE model has been used using data for the period of 2011–2014 and its suitability has been evaluated by comparing its estimates with the observed bathymetric data. The model was found to estimate the erosion rate with fair degree of accuracy. The average recent erosion rate for the catchment comes out to be 34.27 t ha^{-1} y^{-1}. The slope and steepness factor is found to have a major effect on the erosion process in the catchment. About 56% of the catchment area is observed to have high to very severe soil erosion rates. It is, however, observed that the recent erosion rates in the catchment are significantly reduced compared to the erosion rates in the initial years after the construction of the lake. This significant reduction is observed to be less due to the support practices of construction of silt detention dams and terracing etc., and more due to the cover management practices like extensive reforestation and plantation undertaken in the catchment.

Keywords Conservation practices · GIS · Remote sensing · RUSLE model · Soil erosion · Sukhna Lake

1 Introduction

Erosion and sediment dynamics have important implications on the sustainable use of natural resources (Walling 2009). Soil erosion and its subsequent deposition in the water bodies is one of the serious problems of many lakes and reservoirs, causing reduction in

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Impact of Black Carbon and Other Aerosols on Himalayan Glaciers: A Brief Review

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Abstract: Black carbon aerosol plays a unique and important role in Earth's climate system to rise the average global surface temperature, thus responsible for warming the globe. Black carbon (BC) is a type of carbonaceous material with a unique combination of physical properties. These assessments provide an evaluation of black-carbon climate forcing that is comprehensive in its inclusion of all known and relevant processes and that is quantitative in providing best estimates and uncertainties of the main forcing terms: direct solar absorption, ice clouds and accumulation of snow/ice over the Himalayan glaciers. Any changes in the total radiative forcing would lead to drastic changes in the impact of BC aerosols over the glaciers and affect downstream flows of melt water streams emanating from glaciers as well as micro-climatic condition of the terrain.

Keywords: Black carbon; Aerosols; Himalayas; Glacier; Climate.

Introduction

Aerosols enhance the back scattering of solar radiation and lead to negative radiative forcing while the absorbed Black Carbon (BC) aerosols lead to the positive effect. Aerosol, the optically absorbing part of the carbonaceous aerosols, is the major anthropogenic component of the atmospheric aerosol system. It is one of the important constituents of ambient particulate matter, which is emitted into the atmosphere as a by-product of combustion processes such as fossil fuels, forest fire, industrial effluent etc. The increase in anthropogenic emission would increase in aerosol loading, thereby reducing the incoming solar radiation reaching to the ground surface. These effects influence regional aerosol radiative forcing (Nair et al., 2013; Haywood and Shine, 1997). Studies at high altitude sites in the Himalayas are particularly important to understand their role in radiative forcing and, more importantly, the melting of Himalayan glaciers, as these sites are also influenced by BC emissions from a variety of source locations (Kopacz et al., 2011; Bond et al., 2013).

Concentration of BC vary in the clean environments of the Antarctica, and high altitude regions. However, observations of higher concentrations of Aitken particles during the high Sun periods suggest generation of nucleation mode particles by photochemical reactions and thermodynamical processes. Low surface area provided by the aerosols at high altitude regions and the presence of high concentration of sulphate and di-methyl sulphide (DMS) at high altitude regions in Himalaya are proposed as possible source for generation of such ion/particles/BC aerosols during High Sun periods. One of the possible sources of BC in Himalayan region may be transportation of polluted material through wind from Indo Gangetic Plain (IGP).

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Application of the Schmidt-hammer with relative-age dating of moraine boulders – a case study from Mandakini River valley, central Himalaya, India

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Abstract: Recent developments in dating applications for paleoclimatic reconstruction have highlighted the inherent problems in dating of glacial environments. We have applied the Schmidt-hammer relative age dating approach on moraine boulders of Mandakini River valley, central Himalaya, India to establish the relative age dating constrain along with published absolute chronologies. The chronologically constrained landforms of the Mandakini River valley represent the four sets of glacial advancement and several set of glacial retreat phases. The Schmidt hammer rebound values (R-values) were collected from 13 locations at different altitude, with 40 impacts on each boulder per site and a total number of 520 values. The average rebound (R)-values for the Rambara Glacial Stage (RGS) are 37, Ghindurpani Glacial Stage (GhGS) are 47, Garuriya Glacial Stage (GGS) are 56 and Kedarnath Glacial Stage (KGS) are 63. We have suggested that the average rebound (R) values of glacial stages are found to be in linear relation with the published Optically Stimulated Luminescence (OSL) and Terrestrial Cosmogenic Nuclide (TCN) chronology. Considering the easy and economical nature of Schmidt-hammer rebound (SHR) technique, we are postulating that by generalizing the R-values for the rock types of glaciated terrains, this can be applied to high and remote altitude environments where the suitable datable materials are difficult to find. With an advent of that, we anticipate that such efforts can be another step for developing a acceptably accurate age calibration curves to reduce the requirement of absolute chronologies in glacial environment.

Keywords: Schmidt hammer, relative age dating, glacial chronology, central Himalaya.

हिमोढ़ गोलाश्मों की तुलनात्मक आयु तथा श्मिड–हैमर अनुप्रयोग– मंदाकिनी घाटी, मध्य हिमालय, भारत से एक उदाहरण अध्ययन

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सारांश: पुरा जल वायवीय स्वरूपण निर्धारण के क्षेत्र में वर्तमान स्थितियों से हिमनदीय वातावरण काल निर्धारण के लिये अन्तर्भूत समस्याएँ परिलक्षित होती हैं। हमने मन्दाकिनी नदी घाटी, मध्य हिमालय में हिमनद गोलाश्मों की तुलनात्मक आयु जानने के लिये श्मिड–हैमर आयु निर्धारण तकनीक का प्रयोग किया तथा उनकी पूर्व प्रकाशित आंकिक आयु से तुलना की। भू–आकृतियों की आयु निर्धारण विधियों से मन्दाकिनी घाटी में चार हिमनदीय तथा कई हिमनद विगलन काल पाये गये हैं। भिन्न भिन्न ऊँचाइयों के 13 स्थानों पर प्रति गोलाश्म 40 प्रहार के अनुसार कुल 520 श्मिड–हैमर पुनरावर्तित मूल्य (रीबाउण्ड अर्थात आर वैल्यूज) प्राप्त किये गये। राम्बारा हिमनद अवस्था (आर जी एस) के लिये औसत आर मूल्य 37, घिंदुर्पानी हिमनद अवस्था (जी ए जी एस) के लिये 47, गरूडिया हिमनद अवस्था (जी जी एस) के लिये 56 तथा केदारनाथ हिमनद अवस्था (के जी एस) के लिये 63 मिले। हमारा मत है कि ये हिमनद अवस्थाओं के रीबाउण्ड मूल्य प्रकाशित ऑप्टिकली स्टिम्यूलेटेड ल्यूमिनिसेंस (ओ एस एल) तथा टेरिस्ट्रियल कॉस्मोजेनिक न्यूक्लाइड (टी एस एन) कालानुक्रम के साथ रैखिक सम्बन्ध प्रदर्शित करते हैं। श्मिड–हैमर रीबाउण्ड तकनीक की सरलता तथा आर्थिक दृष्टि से सहजता को देखते हुए हमारा अनुमान है कि इस प्रकार प्राप्त हिमनद अवस्थाओं के आर मूल्यों का सामान्यीकरण करते हुए इस तकनीक का प्रयोग अधिक उँचाई वाले तथा दुर्गम वातावरणों में भी किया जा सकता है जहाँ से अन्य उपयुक्त काल निर्धारण सामग्री नहीं प्राप्त की जा सकती। इसके प्रयोग से हम आशा करते हैं कि हिमनद वातावरण के आंकिक काल की आवश्यकता को कम करने में इस प्रकार के प्रयत्न अधिक स्वीकार्य तथा यथार्थ काल निर्धारण वक्र प्राप्त करने की दिशा में एक कदम होंगे।

सूचक शब्द: श्मिड हैमर, तुलनात्मक काल मापन, हिमनद कालक्रम, मध्य हिमालय।

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ORIGINAL ARTICLE

Mapping groundwater prospect zones in an intermontane basin of the Outer Himalaya in India using GIS and remote sensing techniques

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Abstract
In India, groundwater is the major source for fulfilling domestic and commercial water requirements. Since groundwater levels in various regions have been decreasing at a much faster rate in the last few decades, it has become important to delineate potential new zones of groundwater to meet future requirements. The intermontane basins in the Outer Himalaya have the potential to hold significant amount of subsurface water in a region that is currently water deficient. The present study discusses groundwater prospect zonation in the Soan Basin of the Outer Himalaya in Una District of Himachal Pradesh in India. ASTER DEM, LANDSAT 8 satellite data and existing geological mapping of the Himalayan foothills were used to prepare a groundwater prospect map of the Soan Basin. Various thematic maps including maps of geomorphology, drainage and land use map were prepared using LANDSAT 8 Satellite data and a geological map of Himalayan foothills using ARC GIS 10.0. Watershed and slope maps were extracted from ASTER DEM with 30 m resolution. A groundwater prospect map was prepared by overlaying the various thematic maps and was subdivided into five potential zones on the basis of potential discharge conditions. These are: regions bearing very low [< 50 L per minute (LPM)]; low (50–100 LPM); moderate (100–400 LPM); high (400–800 LPM); and very high (> 800 LPM) potential zones of groundwater. The high and very high potential zones are located in the central synclinal valley along the fluvial terraces, alluvial fans and piedmont deposits. The low and very low potential zones lie in the hilly areas with high slopes and rugged topography causing rapid downslope movement of water, which results in less infiltration and consequently deeper groundwater levels with a low groundwater potential.

Keywords Groundwater · Himalaya · Intermontane basin · Remote sensing

Introduction

Groundwater is the primary source of water for human consumption and is the major resource for fulfilling domestic as well as commercial needs. Globally, more than 60% of agricultural practices are dependent upon groundwater as a water source (World Bank report 2012). Over the last few decades, increasing agricultural and industrial demand for water along with increasing urbanization due to rising populations have led to the overexploitation of Earth's water/groundwater, which in turn is affecting the water level/table and, thus, its availability. A number of regions in India have experienced a trend toward a decreased availability of freshwater (Srivastava et al. 2012). Therefore, there is an urgent need to map the regions having potential to hold substantial resources of groundwater for future uses. Water prospecting includes the identification of areas or regions which act as potential aquifers. The yield of aquifers, however, depends on the topographic and geomorphic features present in a particular region, geological and structural controls that might influence groundwater movement, hydrogeological conditions and potential recharge sources.

Since the water holding capacity of an aquifer is largely dependent on the physical characteristics of rocks in the subsurface, an adequate knowledge of geology, geomorphology and hydrogeological conditions in a given region is essential (Srivastava et al. 2012). Regions that have steep slopes and sparse vegetation usually reflect the scarcity of water and low rates of groundwater discharge from aquifers. The

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Late Quaternary glaciation history of monsoon-dominated Dingad basin, central Himalaya, India

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ABSTRACT

The study presents the Late Quaternary glaciation history of monsoon-dominated Dokriani Glacier valley, Dingad basin, central Himalaya, India. The basin is tested for the mechanism of landforms preservation in high relief and abundant precipitation regimes of the Higher Himalaya. Field geomorphology and remote sensing data, supported by Optical Stimulated Luminescence (OSL) dating enabled identification of five major glacial events of decreasing magnitude. The oldest glacial stage, Dokriani Glacial Stage I (DGS-I), extended down to ~8 km (2883 m asl) from present-day snout (3965 m asl) followed by other four glaciations events viz. DGS-II, DGS-III, DGS-IV and DGS-V terminating at ~3211, 3445, 3648 and ~3733 m asl respectively. The DGS-I glaciation (~25–~22 ka BP) occurred during early Marine Isotope Stage (MIS) −2, characterized as Last Glacial Maximum (LGM) extension of the valley. Similarly, DGS-II stage (~14–~11 ka BP) represents the global cool and dry Older Dryas and Younger Dryas event glaciation. The DGS-III glaciation (~8 ka BP) coincides with early Holocene 8.2 ka cooling event, the DGS-IV glaciations (~4–3.7 ka BP) corresponds to 4.2 ka cool and drier event, DGS-V (~2.7–~1 ka BP) represents the cool and moist late Holocene glacial advancement of the valley. This study suggests that the Dokriani Glacier valley responded to the global lowering of temperature and variable precipitation conditions. This study also highlights the close correlation between the monsoon-dominated valley glaciations and Northern Hemisphere cooling events influenced by North Atlantic climate.

1. Introduction

Glaciers respond in terms of a shift in mass balance to the climate system and provide a proxy to quantify the change at regional as well as global scale (Yao et al., 2012). The reconstruction of past glaciations/deglaciation patterns by obtaining the meaningful chronology is an important tool to develop a possible theory for glacial response to climate. The modern glaciation theories for Himalayan-Tibetan orogen explain the climatic forcing and magnitude of extension as cause and effect problem on the regional and global scale (Owen and Dortch, 2014 and references therein). The spatio-temporal correlation of glacial chronologies underline the inherent factors of climatically divisible topography, precipitation, temperature and help to understand the mechanism of glaciation in Himalaya (Egholm et al., 2009; Zech et al., 2009; Kirkbride and Winkler, 2012; Ali et al., 2013; Owen and Dortch, 2014; Bisht et al., 2015). Although, the evidences preserved in different valleys for Last Glacial Maximum (LGM; 18–24 ka) tests the hypothesis for climatic fluctuations over space and time (Mix et al., 2001; Zech et al., 2009; Scherler et al., 2011; Bali et al., 2013; Ali et al., 2013; Mehta et al., 2014). Nevertheless, an overarching explanation for inferred differences is proposed in terms of climate system variables (temperature and precipitation; Zech et al., 2009). The glaciation in Arid zones of the Himalaya is precipitation sensitive, and that in the humid settings are temperature sensitive; while the transition climatic settings shows its sensitivity for both precipitation and temperature (Scherler et al., 2011; Mehta et al., 2012, 2014; Dortch et al., 2013; Ali et al., 2013; Murari et al., 2014; Sati et al., 2014; Bisht et al., 2015; Kumar et al., 2017).

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Groundwater quality assessment of the Soan Basin in Outer Himalaya, Himachal Pradesh, India

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Abstract: The paper discusses the ionic sources and assesses the chemical quality of groundwater of the Soan Basin in Outer Himalayan region of Himachal Pradesh for drinking and irrigation purposes through several water quality assessment indices. A total of 205 groundwater samples were collected from tube wells, hand pumps and dug wells and analysed for major ions. The ions are mainly derived from chemical weathering process occurring between water and catchment lithology comprising conglomerate and sandstone rocks of the Siwalik formation and locally altered by anthropogenic activities. The water is hard to very hard in nature with total hardness as high as 468.3 mg/l. Further, WQI shows a slight deterioration of water quality from pre-monsoon to winter season in the hill region. However the water around the Una district falls under the category of good water. The electrical conductivity, % Sodium, Sodium Adsorption Ratio, Kelley's Ratio and Magnesium Ratio indicate that the water can be used for irrigation under most of the conditions. The majority of the samples fall under C2S1 and C3S1 categories on US salinity diagram and good to permissible category on Wilcox diagram. Samples with high sodium and calcium content along with high EC fall under C3S2 and C3S4 category reflecting their unsuitability for irrigation in the pre-monsoon (PRM), post-monsoon (POM) and winter season. High nitrate and sodium concentrations in the groundwater are associated with fertilizers used to increase agriculture output. Majority of the ions are present within the permissible limit of BIS, 2012 standards for drinking water indicating the suitability of groundwater for drinking purposes.

Key words: Groundwater Quality, Outer Himalaya, Water quality indices.

सारांश: पेपर आयनिक स्रोतों पर चर्चा करता है ओर हिमाचल प्रदेश के बाहरी हिमालयी क्षेत्र में स्रोत बेसिन के भूजल की रासायनिक गुणवत्ता का मूल्यांकन कई जल गुणवत्ता निर्धारण मापदंडों के माध्यम से पीने और सिंचाई के उद्देश्यों के लिए करता है। टयूबवेल्स, हैंडपंप और डगवेल से कुल 205 भूजल के नमूने एकत्र किए गए और प्रमुख आयनों के लिए विश्लेषण किया गया। आयन मुख्य रूप से रासायनिक अपक्षय प्रक्रिया से आते है जो पानी और पकड़ लिथोलॉजी के बीच होती है जिसमें सिवालिक गठन के समूह और बलुआ पत्थर चट्टान होते हैं और स्थानीय रूप से मानववंशीय गतिविधियों द्वारा बदला जाता है। पानी की अधिकतम कठोरता 468.3 मिलीग्राम / प्रति लीटर है जिस कारण यह कठोर से अधिक कठोर द्रोणी में आता है। इसके अलावा, डब्ल्यूक्यूआई पहाड़ी क्षेत्र में पूर्व मानसून से सर्दी के मौसम तक पानी की गुणवत्ता में मामूली गिरावट दिखाता है। हालांकि उना जिले के आसपास का पानी अच्छे पानी की श्रेणी में आता है। विद्युत चालकता, % सोडियम, सोडियम सोखना अनुपात, केली का अनुपात और मैग्नीशियम अनुपात इंगित करता है कि अधिकांश स्थितियों के तहत पानी का उपयोग सिंचाई के लिए किया जा सकता है। अधिकांश नमूने यूएस लवणता आरेख पर सी 2 एस 1 और सी 3 एस 1 श्रेणियों के अंतर्गत आते हैं और विल्कोक्स आरेख पर अनुमत श्रेणी के लिए अच्छा है। उच्च ईसी के साथ उच्च सोडियम और कैल्शियम सांद्रता वाले नमूने सी 3 एस 2 और सी 3 एस 4 श्रेणी के तहत गिरते हैं जो मानसून (पीआरएम), मानसून के बाद (पीओएम) और सर्दी के मौसम में सिंचाई के लिए अपनी अनुपस्थिति को दर्शाते हैं। भूजल में उच्च नाइट्रेट और सोडियम सांद्रता कृषि उत्पादन में वृद्धि के लिए उपयोग किए जाने वाले उर्वरकों से जुड़ी हैं। अधिकांश आयन बी आई एस (2012) द्वारा दी गई स्वीकार्य सीमा के भीतर मौजूद हैं जो पीने के पानी के लिये भूजल की उपयुक्तता दर्शाती है।

संकेत शब्द: भूजल गुणवत्ता, बाहरी हिमालय, जल गुणवत्ता सूचकांक।

INTRODUCTION

The groundwater quality of a region depends mainly on soil and rock characteristics of its catchment area, groundwater velocity, quality of recharge water, anthropogenic activities (agriculture, industry, urbanization and increasing exploitation of water resources) and atmospheric inputs (Helena *et al.* 2000, Chan *et al.* 2001, Dudeja *et al.* 2011, Haque *et al.* 2013, Tiwari & Singh 2014, Machiwal & Jha 2009, Choudhary *et al.* 2016, Tolera *et al.* 2017). Further, pollution and water quality degradation interfere with vital and legitimate water uses at every scale varying from local, regional, and global (Meyback *et al.* 1987). While considering the water for irrigation, excess or scarcity of some nutrients and ions mainly Na^+, Cl^-, Mg^{2+} etc. in water adversely affect the composition, structure, permeability and porosity of soil and ultimately the crop yield and the excess of Mg^{2+}, NO_3^-, Ca^{2+} and SO_4^{2-} etc. and presence of Total coliform and E-Coli in drinking water lead to many health problems in humans.

Although several studies on water quality issues have been carried out in different parts of the country (Shankar *et al.* 2008; Avtar *et al.* 2013; Samanta *et al.* 2013; Choudhary *et al.* 2016), studies from the Himalaya are limited because water from Himalayan region is considered as pristine. However, reports of deteriorating water quality from Nepal and Uttarakhand regions of the Himalaya (Jenkins 1995; Bartarya 1995; Dudeja et *al.* 2011; Bartarya & Deoli 2012; Deoli *et al.* 2017) and declining water table and deteriorating water quality of the aquifers along the Ganga Basin (Misra, 2011)

Estimation of ice thickness of the Satopanth Glacier, Central Himalaya using ground penetrating radar

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Total volume of stored ice in the Himalayan glaciers is an important quantity for water resource management of the Himalayan catchments. However, direct measurement of glacier-ice thickness is rare in the Indian Himalaya. We have estimated the ice thickness of the debris-covered Satopanth Glacier (SPG) using a ground penetrating radar (GPR). Multiple bistatic, unshielded antennae with frequencies of 16, 20, 40 and 80 MHz were used for this purpose. We have done GPR surveys at various locations over the ablation zone of SPG. However, satisfactory results were obtained only on two transects. Near the glacier snout, a transverse GPR profile shows an ice thickness of 38 ± 3.5–50 ± 3.5 m. We have obtained 98 ± 7–112 ± 7 m ice thickness at a longitudinal transect in the upper ablation zone. To measure the speed of the radar waves in ice, a common midpoint survey was carried out. Our results for the speed of the electromagnetic waves are slightly lower than the standard values of such waves through pure ice.

Keywords: Common midpoint survey, debris-covered glaciers, ground penetrating radar, ice thickness.

Introduction

THE Himalayan cryosphere forms a huge reservoir of freshwater. However, the volume estimates of ice are currently uncertain, ranging from about 2300 to 6300 km^3 (refs 1, 2). This large uncertainty is partly due to the fact that ice thickness cannot be measured directly by remote-sensing techniques and is estimated using a variety of approximate models[2–7]. It is, therefore, important to perform direct field measurements of ice thickness for individual glaciers. Such data would help in better calibration and validation of the models, potentially leading to more accurate estimation of the volume of stored ice in the Himalaya. In this study, we estimate the ice thickness of the Satopanth Glacier (SPG), Central Himalaya, using ground penetrating radar (GPR) survey.

GPR is a well-established technique to study subsurface features[8,9]. In the bistatic configuration that we have used for our surveys, pulses of radio waves are generated and transmitted by the transmitter antenna. The pulses propagate through the medium and generate reflections from subsurface inhomogeneities in the refractive index. These reflected signals are detected by the receiver antenna and are recorded as a function of time. The spatial pattern and depth of the subsurface features that cause the inhomogeneities can be reconstructed by an analysis of the measured delays in the reflected signals. In the context of a glacier, the reflectors could be englacial features like embedded boulders, crevasses, subglacial till, ice-flow features and the bedrock. The bedrock is distinguished from other englacial features by the fact that it is a spatially continuous reflector, unlike other localized objects. The resolution and penetration depth of GPR are determined by antenna frequency and electromagnetic properties of the surveyed materials[9]. Due to high rates of signal attenuation, penetration depths are greatly reduced in ice with high water content. The higher the electrical conductivity of the melt water, the stronger is the dissipation. Both these issues lead to serious difficulties in GPR studies of the Himalayan glaciers, more so for the debris-covered ones.

Ice-thickness measurements by GPR are sparse in the Himalaya. In the Indian Himalaya, possibly the first attempt to estimate thickness was made on Dokriani glacier of Central Himalaya using a 12.5 MHz central frequency antenna[10]. The ice thickness of this glacier calculated by GPR survey ranges from 15 to 25 m near the snout to 120 m in the accumulation zone. Ice-thickness measurements of this Patseo and Samudra Tapu glaciers in Chandra-Bhaga basin of Western Himalaya were made using 50, 100 and 500 MHz frequency antennae[11]. The depth of the Patseo Glacier at one location was estimated as 40 m, but ice thickness of the Samudra Tapu Glacier could not be measured using 50 and 100 MHz frequency antennae. GPR profile on a

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ORIGINAL ARTICLE

Tracing ionic sources and geochemical evolution of groundwater in the Intermountain Una basin in outer NW Himalaya, Himachal Pradesh, India

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Abstract

The present research aims to identify sources of ions and factors controlling the geochemical evolution of groundwater in an intermountain basin, comprising hill and valley fill region, of Outer Himalaya in Himachal Pradesh, India. The groundwater samples collected from 81 tubewells and handpumps are analyzed for major ions, trace metals and stable isotopes ($\delta^{18}O$ and δD). Geochemically the dominant hydrochemical facies in the Una basin are Ca–HCO_3, Ca–Mg–HCO_3 and Na–Cl types at few locations. A relatively lower ionic concentration in the valley fills indicates dilution and low residence time of water to interact with the aquifer mass due to high porosity and permeability. The ionic ratios of 0.9, 0.8 and 3.8 to 5.7, respectively, for (Ca + Mg): HCO_3, (Ca + Mg): ($HCO_3 + SO_4$) and Na: Cl, suggests that ionic composition of groundwater is mainly controlled by rock weathering of, particularly by dissolution/precipitation of calcrete and calcite hosted in rock veins and Ca–Na feldspar hosted in conglomerate deposits derived from the Higher and Lesser Himalaya during the formation of Siwalik rocks. Although Na, K, NO_3 and SO_4 are introduced in the groundwater through agricultural practices, Na has also been introduced through ion exchange processes that have occurred during water–rock interaction, as indicated by negative CAI values. Factor analysis further suggests three major factors affecting the water chemistry of the area. The first two factors are associated with rock weathering while the third is anthropogenic processes associated with high nitrate and iron concentration. High concentrations of Fe and Mn ions that are exceeded that of WHO and BIS standards are also present at few locations. The recharge of groundwater in the Outer Himalaya is entirely through Indian Southwest Monsoon (ISM) and depleted ratios of $\delta^{18}O/\delta D$ in valley region indicate infiltration from irrigation in recharging the groundwater and fractionation of isotopes of precipitation due to evaporation before infiltration. High d-excess values and inverse relation with $\delta^{18}O$ are indicative of secondary evaporation of precipitation during recharge of groundwater.

Keywords Intermountain basin · Outer Himalaya · Groundwater · Ionic sources · Geochemical evolution

Introduction

The variation in the groundwater chemistry in a region is greatly influenced by the geological background (e.g. rock property, mineralogical composition, etc.) and secondarily through undergoing anthropogenic processes. Depending on the geology of an area, the spatial and temporal variation in the hydrochemical composition of groundwater is impacted by various factors such as mixing, precipitation, dissolution, etc. (Domenico and Schwartz 1998; Nwankwola and; Udom 2011). Thus, a probable direction of groundwater movement can also be identified through the spatial distribution of the chemical constituents of groundwater (Kumar et al. 2006). The geochemical and isotopic indicators have been widely used to identify the ionic and recharge sources of groundwater and interaction between groundwater and surface water (Yuko et al. 2002; Yang et al. 2012a, b). In addition, the relative concentration of major ions in groundwater from different aquifers can provide information about the geochemical reactions occurring within the aquifer mass and the

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Stability analysis of rock cut slopes along the Minas road between Ichhari Dam and Minas Bridge, Tons valley, Garhwal Himalaya

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Abstract: Slope failures are common in Himalayan terrain. Highways become more vulnerable to slope failures due to road cutting and widening, expansion of towns and markets settled along the highway, erosion and toe cutting by large rivers and their tributaries etc. The present study incorporates detailed geological mapping and delineation of weak zones prone to slope failures along the Minas road between Ichhari Dam and Minas Bridge. Slope stability analysis of a number of slopes along the Minas road has been carried out. Study of joints was carried out at 63 locations along 40 km road section of study area. Slope Mass Rating (SMR) was calculated on a number of outcrops exposed along the road cut slope. Kinematic analysis by Markland's Method has been utilized to decipher the possible mode of failures and their directions. Considering the similarity in lithology and orientation of joints, the road section has been divided into ten sectors to identify the role of structural discontinuity in weakening of rocks and slope failures.

Keywords: Slope stability, Slope mass rating, Kinematic analysis, Tons valley.

सारांश: हिमालयी क्षेत्र में ढलानों की विफलता सामान्यतः होती है। सड़क काटने और चौड़ी करने, राजमार्ग के साथ बसे शहरों और बाजारों के विस्तारण, बड़ी नदियों और उनकी सहायक नदियों आदि के द्वारा किये गये क्षरण/आधार कटाव के कारण राजमार्गों के ढलान अधिक कमजोर हो जाते हैं। वर्तमान अध्ययन में, इछाड़ी बांध और मिनस ब्रिज के मध्य मिनस सड़क का विस्तृत भूवैज्ञानिक मानचित्रण और कमजोर–ढलान क्षेत्रों का चित्रण शामिल है। मिनस सड़क के साथ–साथ स्थित कई ढलानों की ढलान स्थिरता का विश्लेषण किया गया है। अध्ययन क्षेत्र के 40 कि0मी0 सड़क–खंड में स्थित 63 स्थानों पर चट्टानों में पायी गयी संधियों का अध्ययन किया गया है। मार्कलैण्ड पद्धति का उपयोग करते हुए काइनेमैटिक विश्लेषण द्वारा चट्टानों की संभावित विफलता–प्रकार एवं दिशा को समझने के लिए किया गया है। रोड़–कट–स्लोप में पाये गये दृश्यांश से स्लोप–मास–रेटिंग (एस0एम0आर0) की गणना की गई है। लिथोलाजी और संधियों के अभिविन्यास की समानता को ध्यान में रखते हुए चट्टानों को कमजोर करने तथा ढलान–विफलताओं में संरचनात्मक असंतुलन की भूमिका की पहचान करने के लिए सड़क–खंड को दस क्षेत्रों में बांटा गया है।

संकेत शब्द: ढलान स्थिरता, स्लोप–मास–रेटिंग, काइनेमैटिक विश्लेषण, टोंस घाटी।

INTRODUCTION

Landslide activities are intimately associated with the tectonically active Himalayan Mountains (Sarkar & Kanungo 1995; Rautela & Thakur 1999; Nainwal & Prasad 2001; Anbalagan *et al.* 2008; Umrao *et al.* 2011; Chauhan *et al.* 2010; Singh *et al.* 2015; Gupta & Tandon 2015; Asthana & Sah 2007). Slope failure is a natural process in hilly terrain but the human intervention has made it more complex, frequent and instance. According to the Schuster (1996), the trend is expected to continue in future also due to increased unplanned urbanization and development, continued deforestation and increased regional precipitation. Heavy and prolonged rainfall causes the over saturation of slope material and increases erosional power of streams. Slopes which are stable today may be unstable in future due to natural and anthropogenic activities operating over the slopes.

In the past two decades, Okhimath landslide in Mandakini valley (Sah & Bist 1998), Phata Byung landslide of Mandakini valley (Naithani *et al.* 2002; Chaudhary *et al.* 2010), Kaliasaur landslide, Alaknanda valley (Nainwal 2002), Budha Kedar landslide in Balganga valley (Sah *et al.* 2003), Varunawat landslide in Bhagirathi valley (Gupta & Bist 2004), Agastyamuni landslide in Mandakini valley (Rautela & Pande 2005), Malpa rockfall in Kali valley (Pant & Luirei 2005), natural hazards in Alaknanda valley (Joshi & Kumar 2006), landslide in Pithoragarh district (Sarkar & Kanungo 2010), Amiyan landslide Kathgodam, Uttarakhand (Singh *et al.* 2013) and landslides in Asi Ganga valley, Uttarkashi (Gupta *et al.* 2013; Martha & Kumar 2013) have devastatingly affected the Uttarakhand.

There are several approaches of slope stability analysis like analytical and kinematic, physical and numerical techniques. Slope mass rating (SMR) technique is one the most adequate and widely used technique proposed by Romana (1985). SMR is based on the rock mass rating (RMR) technique (Bieniawski 1979). In the present study, stability analysis of rock cut slopes is carried out using the SMR approach (Romana 1985).

STUDY AREA

The study area is located between latitude 30°35'46"-30°46'55"N and longitude 77°41'12"-77°49'25"E (Fig. 1).The study area lies along the right bank of Tons River along Minas road between Ichhari Dam and Minas Bridge in Dehradun district of Uttarakhand. This part of study area falls in the Survey of India Toposheet No. 53F/10, 53F/14. River Tons is one of the largest tributaries of river Yamuna draining in the study area. The area has temperate climate with warm summer

General Geomorphological Field Observations around Satopanth Glacier Area, Garhwal Himalaya, Uttarakhand

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Abstract: Upper Alaknanda valley from the head wall of Satopanth glacier, till village Mana houses distinct geomorphology which is full of glacical, glacio-fluvial and peri-glacial features. Starting from village Mana a distinct U-shaped valley is observed, the valley wall has a sharp contact with the glacial trough line making vertical cliffs over which there are hanging valleys from which waterfalls pour their water into the valley floor. The trough line roughly denotes first glacial advancement stage of the valley. Moving further in the valley various features like fluvial terraces are observed along the river bank concealed under thick veneers of slope wash material forming talus fans through which river Alaknanda has carved a V-shaped valley. The glacier out wash plain is filled with erratic boulders and other glaciogenic material like terminal and recessional moraines. The erosional and depositional features in this area indicate two more glacial advancements in this area. Further the valley takes sharp left turn with relatively steeper slope of 200-300 m after which snout and front of Satopanth glacier can be observed. Besides this numerous other features like lateral moraines, recessional moraines, supra-glacial moraines, ablation valleys, lateral basins, supra-glacial ponds, pro-glacial lake, lateral basin lakes, crevasses and Patterned ground etc., are observed which were formed due to various glacial and peri-glacial activities.

Key Words: *Geomorphology, Satopanth Glacier, Garhwal Himalaya*

Introduction

Study area lies in the upper Alaknanda basin in Chamoli district, Uttarakhand Himalaya. The major portion of study area falls in the Survey of India topographic map no. 53N/5, 53N/6, N/1 and is located between latitude 30°42′55′′-30°50′32′′N and longitude 79°13′55′′-79°29′40′′E (Fig.1). Satopanth glacier has five major tributary glaciers namely Luri Bamak, T1, T2, T3 and T4 glaciers, of these Luri Bamak meets the trunk glacier at the left bank whereas T1,T2, T3 and T4 meet the trunk glacier at the right bank. Satopanth glacier (SPG) and its adjoining Bhagirath Kharak (BKG) glacier are the sources of river Alaknanda and river Uttarganga respectively, both of which meet approximately 1 km downstream of Satopanth glacier just before Alkapuri, from where the river is known as Alaknanda. From Alkapuri after travelling ~8 kms River Alaknanda meets River Saraswati at Keshav Prayag near Mana village. The upper Alaknanda watershed covers an area of 234.35 km^2 out of which 70.70 and 107.22 km^2 are covered by Satopanth and Bhagirath Kharak watersheds respectively.

The E-W trending SPG and BKG are approximately 13 and 18.5 km long with an average width of 750-850 m, covering an area of ~19.0 and 31.0 km^2 respectively. The gradient of SPG (0.152) is comparatively higher than that of the BKG glacier (0.143) (Nainwal et al. 2008 & 2016). A linear ridge known as Balakun divides these two glacier trough and ends abruptly towards the eastern end near the junction of the lateral moraine of these two glaciers at Kunaling. The snouts of SPG and BKG glaciers are located at an altitude of around 3860 and 3760 m asl respectively. Both of these glaciers emerge from the eastern slopes of Chaukhamba group of peaks. The Pawegarh ridge (5288-6165 m asl) marks the northern boundary of the upper Alaknanda basin and is a water divide between Alaknanda and Saraswati catchments, Nilkanth (6596 m asl)– Chaukhamba (7138 m asl) ridge is the southern boundary which divides Alaknanda catchment from Rishiganga and Mandakini catchments. The Chaukhamba (~6288–7138 m asl) on the west, divides Alaknanda catchment from Bhagirathi catchment.

Geology

Geologically, the study area falls under Higher Himalayan Central Crystalline Zone, described as Himadri Complex. Lithology of the area is dominated by calc-silicate with sillimanite-kyanite-garnet-biotite gneiss and

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Paper

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Estimation of the total sub-debris ablation from point-scale ablation data on a debris-covered glacier

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Abstract

Glaciological ablation is computed from point-scale data at a few ablation stakes that are usually regressed as a function of elevation and averaged over the area-elevation distribution of a glacier. This method is contingent on a tight control of elevation on local ablation. However, in debris-covered glaciers, systematic and random spatial variations of debris thickness modify the ablation rates. We propose and test a method to compute sub-debris ablation where stake data are interpolated as a function of debris-thickness alone and averaged over the debris-thickness distribution at different parts of the glacier. We apply this method on Satopanth Glacier located in Central Himalaya utilising ~1000 ablation measurements obtained from a network of up to 56 stakes during 2015–2017. The estimated mean sub-debris ablation ranges between 1.5±0.2 to 1.7±0.3 cm d^{-1}. We show that the debris-thickness-dependent regression describes the spatial variability of the sub-debris ablation better than the elevation dependent regression. The uncertainties in ablation estimates due to the corresponding uncertainties in the measurement of ablation and debris-thickness distribution, and those due to interpolation procedures are estimated using Monte Carlo methods. Possible biases due to a finite number of stakes used are also investigated.

Introduction

Extensive supraglacial debris mantle on the ablation zone modifies glacier response to climate forcing (Scherler and others, 2011a; Nuimura and others, 2012; Banerjee and Shankar, 2013; Gardelle and others, 2013; Brun and others, 2017; King and others, 2018). The supraglacial debris layer mediates the melt-energy supply to the ice-surface underneath. A thick debris layer inhibits melt by insulating the ice, whereas a thin-debris layer increases melt due to a lower albedo (Østrem, 1959; Collier and others, 2014). However, in the limit of a very thin debris layer (≤2 cm), increased evaporation reduces the energy available for melting (Collier and others, 2014) leading to a decline in ablation (Østrem, 1959). Supraglacial debris advects with the ice flow, and the debris layer generally thickens down-glacier as the ice velocity declines (Benn and Lehmkuhl, 2000; Kirkbride and Deline, 2013; Anderson and Anderson, 2016). This thickening of debris layer causes a systematic reduction in ablation rate down-glacier, even though elevation decreases. This is in contrast with the down-glacier increase in ablation which is typically seen on debris-free glaciers (e.g., Oerlemans, 2001). The resultant inverted mass-balance profile on the debris-covered ablation zone has profound implications on the evolution of a glacier under a warming climate (Banerjee and Shankar, 2013). The most striking feature of which is a decoupling of length and mass changes of the glacier right after the warming starts: a thickly debris-covered glacier initially loses mass mostly by thinning, even as its length remains steady over a period of stagnation that may span several decades (Naito and others, 2000; Banerjee and Shankar, 2013). A combination of a slow evolution of the ice-flux patterns under the climate forcing and low melt rates beneath the debris cover are responsible for the formation of the stagnant tongue. Beyond this the period of stagnation, a relatively high net mass-loss rate is expected on debris-covered glaciers (Banerjee, 2017). With an extensive supraglacial debris cover over 40% of the total ice mass in the ablation zones of several regions in the Himalaya-Karakoram (Kraaijenbrink and others, 2017), the above-mentioned debris effects have left strong imprints in the recent ice-loss pattern in the Himalaya (Scherler and others, 2011a; Nuimura and others, 2012; Banerjee and Shankar, 2013; Gardelle and others, 2013; Brun and others, 2017; King and others, 2018) and may crucially impact its future evolution as well (Kraaijenbrink and others, 2017).

The smooth down-glacier increase in debris thickness, and the corresponding decline of the surface ablation rate as discussed above, provide only a first- order description of the debris effects (Benn and Lehmkuhl, 2000; Scherler and others, 2011b; Banerjee and Shankar, 2013). The role of several other complicating factors, e.g., the presence of numerous thermokarst ephemeral ponds and cliffs that increase local melt rate (Reynolds, 2000; Sakai and others, 2000; Miles and others, 2017), vertical and horizontal variations of the thermal

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Pan coefficients for estimating open-water surface evaporation for a humid tropical monsoon climate region in India

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Pan coefficients have been developed for the Sukhna lake region in Chandigarh, India that has a humid tropical monsoon climate, using the optimisation technique for annual, monthly and seasonal time scales. Evaporation estimated using the Bowen ratio energy budget method has been considered as actual evaporation. Results show that the pan coefficient for the study area varies significantly both by month and season. The month-wise variation is in the range of 0.72–1.40 and the seasonal variation is in the range of 0.81–1.16. Pan coefficients obtained using various existing models such as Cuenca, Snyder, Modified Snyder, Pereira, Orang, FAO-56 and Wahed–Snyder have also been compared with the developed coefficients. Comparative analysis indicates that the pan coefficients obtained using the Snyder model overestimate evaporation significantly, while the rest of the models significantly underestimate evaporation. The study concludes that the developed pan coefficients are observed to estimate the open-water surface evaporation with a fair degree of accuracy for the study area while the pan coefficient value of 0.7 being used by most field organisations in India give high errors. However, since pan coefficients vary spatially due to the variation in the relative significance of various meteorological parameters, the pan coefficients developed in the present study need to be further evaluated for their suitability to other similar climatic regions of India.

Keywords. Chandigarh; Class 'A' evaporation pan; pan coefficient; BREB method; monsoon climate; open-water surface evaporation.

1. Introduction

A number of lakes in India have been facing water scarcity problems in recent times. Watershed management practice, such as the construction of silt detention structures to arrest erosion in the catchment, is one of the main reasons for this water scarcity. This is because, these silt detention structures also act as water-storing structures, thereby abstracting water in the catchment and not allowing it to flow to the water bodies, as in the case of Sukhna lake in Chandigarh, India. As most of these water-retaining structures are very shallow water bodies, quite often shallow sheets of water, evaporation losses from them could be very significant. As such, it is important to understand the impact of evaporation losses from such structures on the run-off from the catchment, which in turn determines the inflow regime of the lakes. Knowledge of evaporation losses from such shallow water bodies is, therefore, very important.

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Geochemistry and geodynamic setting of Paleoproterozoic granites of Lesser Garhwal Himalaya, India

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Abstract

The granite and gneisses rocks are well exposed around Toneta, Tilwara and Chirbatiyakhal region in the Lesser Garhwal Himalaya have less studied which consider as Paleoproterozoic age. The granites from Toneta area are classified as K-rich peraluminous granite with low Na_2O varies from 0.74 to 2.4 wt.% and high K_2O content varies from 5.0 to 6.91 wt.%. The average Al_2O_3 (12.7 wt.%) in the granite is greater than the total alkalies (Na_2O+K_2O = Av. 7.62 wt.%), the TiO_2 content is low ranging from 0.1 to 0.28 wt. %. In the Y + Nb – Rb, Y – Nb, Ta + Yb – Rb, and Yb – Ta discrimination diagram of Pearce et al. (1984) show that the Toneta granites mostly plots within the syn-collision granite fields. This is typical collisional granite.

Keywords: Paleoproterozoic granite, Garhwal Himalaya, syn-collision granite, geodynamic setting, Lesser Himalaya

1. Introduction

To Granites have provided a constant focus for controversy among geologists on account of their inherent diversity and their association with very wide spectrum of geological phenomenon since the beginning of geology in the modern sense which can be arbitrarily judged to date from 1838 with the publication of Lyell's "Principles of Geology" (in Islam et al., 2005).

The Himalayan mountain belt has evolved due to the collision of the Eurasian and Indian Plates and extends along an arc having a convexity towards south (Patriat and Achache, 1984). It measures for about 2400 km in length with a width of about 320 km. The Himalaya is broadly classified as i) Sub-Himalaya, ii) Lesser Himalaya, iii) Higher Himalaya, iv) Tethys Himalaya, and v) Trans Himalaya (Fig. 1a). Lesser Himalayan sequence is separated from the Higher Himalayan crystalline by a deep seated tectonic lineament called Main Central Thrust (MCT; Heim and Gansser, 1939). Fuchs and Sinha (1978), Sinha (1989), Thakur (1992), Gansser (1993) and Saklani (1993) suggest that the MCT is not a single thrust in the Garhwal region, but composed of three tectonic planes i.e. MCT-I, -II and –III developed by the duplex mechanism of thrust tectonics (Fig. 1b; Saklani et al., 1991). The extensive work of Valdiya (1980) from Kumaon Himalaya show that several Paleoproterozoic granites bodies occur in Lesser Himalayan sequence and it found all along the 2000 km Himalayan belt starting from Besham in Swat valley (NW Himalaya) to the Bomdila gneiss in the NE Himalaya (Islam et al., 2005; Phukon et al., 2018 and references therein). The granites occurring in the Himalaya are classified in to four groups (Islam et al., 2005): i) Proterozoic granites (2200 - 1800 Ma; 1400 - 1200 Ma; from Lesser and Higher Himalaya), ii) Early Paleozoic granites (600 - 500 Ma), iii) intrusive phases of Ladakh plutonic complex (102 ± 3 Ma and 42 - 30 Ma), and iv) Tertiary leucogranites (30 - 12 Ma).

Granitic gneisses and granitic augen gneisses exposed in the Lesser Himalayan zone have extended as Proterozoic ages (2200 - 1800 Ma; Table 1). These rocks from Lesser and Higher Himalaya are considering as part of the peninsular India, and the occurrences of granites from Lesser Himalayan sequence are well exposed in Himachal and Garhwal - Kumaon regions (Saklani et al., 1991; Saklani, 1993; Singh et al., 1998). The Outer Himalaya and Indo-Gangetic plain formed, after eroded material from Higher Himalaya during Himalayan orogeny, towards south of Lesser Himalaya.

Research Article

Chemical composition and isotopic signatures of ice and snow over a Himalayan Glacier (Satopanth) in India

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Abstract

This study reports the chemical composition and isotopic signatures of snow and ice over a Himalayan Glacier in India. An observational campaign was carried out from September 22, 2016, to October 2, 2016, over Satopanth in central Himalaya. The pH value of ice and snow, respectively, was 5.6 ± 0.4 and 5.9 ± 0.35 over the glacier, indicating moderate acidity of the glacier components. Calcium (Ca^{2+}) was the dominant component in snow (35.2%), while sulfate (SO_4^{2-}) was dominant in ice samples (52.7%). The neutralization factor was estimated to find the extent of neutralization of acidic fractions by basic components. It is found that Ca^{2+} was the prominent neutralizing factor both in snow and ice over the region. Oxygen and hydrogen isotopic analyses of snow, surface layer ice and debris-covered ice suggest that the moisture source is common for all three components. δD and d-excess values of snow at Satopanth are different than that of those for Chorabari, Dokriani and Tiprabank Glacier, indicating the plausibility of different sources of moisture for these glaciers. Limited observations suggest that the interaction of ice with the debris has no impact on the isotopic signatures of the ice over the region; such non-alteration of isotopic signatures makes the region important for ice core-based paleoclimatic studies.

Keywords Himalayan Glacier · Chemical composition · Snow and ice · Isotopic analysis

1 Introduction

The melting and retreat of glaciers due to global warming have been a major issue in the Himalayan region. Even though major portion of the glaciers in Himalaya are retreating, some portion are remaining stationary or advancing [3, 27, 39]. The dust particles present over glaciers have significant effect in controlling the glacier retreat. It is shown that the high loading of dust works as an insulator and moderates solar heating of the underlying surface [9]. The chemical composition of snow and ice over glaciers indicates the essential minerals and salts present in the glacier, which can account for the climatic and environmental changes [4]. The ionic deposition over glaciers are mainly contributed by circulation patterns and activities in the local environments [24]. Many glaciers in central Himalaya are featured with the covering of soil and stone debris over the ice surface. The climate responses of debris-covered glaciers are poorly understood [3]. It is suggested that debris-covered glaciers can withstand glacier retreat by 45–50% more as compared to the bare glaciers [3]. Since the last century, a number of attempts have been made by several investigators to study the various glaciological aspects of the Himalayan Glaciers (e.g., [6, 12, 17, 20, 23, 27–29], etc). However studies on ionic composition of snow/ice observations are limited, as most of the studies are oriented in the geological perspective over central Himalaya. Hence a campaign mode study was conducted

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Glaciers recession and their impact: Some observation from Panpatiya, Bhagnyu bank and Tipra glaciers using Geospatial methods, Uttarakhand, India

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Abstract:
Glaciers are the indicators of past, present and future climatic conditions of the globe. Nowadays, the earth is passing through the phase of warming; therefore, a majority of the glaciers are retreating together including Himalayan glaciers. Taking a lesson from the 2014 tragedy of Kedarnath, studies of the glacier retreat and consequent hazards are significant and necessary. The retreat of the glaciers might cause a significant threat to the downstream area. As an example, the flood of 2014 (along Khirogad, a tributary of Alaknanda) completely damaged the Vishnuprayag hydroelectric power projects located at Hanuman Chatti area of the valley. Thus, the current study has been focused on the three major glaciers of Uttarakhand i.e., Tipra, Bhagnyu Bank, and Panpatiya glaciers. These three glaciers are located in the Upper Alakananda basin, Chamoli district in the Uttarakhand state of India. Geologically, the area is bounded by high-grade metamorphic rocks which are also known as Himadari Complex. During the course of study, various images and maps were geo-referenced and processed using *Arc GIS software*. Survey of India (SOI) toposheet (1962) has been used as a base map. Snout retreat and area vacated has been calculated with the help of 1962, SOI toposheet and Google Earth's images 2005. The study reveals that in the 43 years (1962-2005), Tipra bank glacier vacated an area of 0.61 sq. km and its average rate of retreat found to be 13.46 m/y. Moreover, Bhagnyu Bank and Panpatiya glaciers vacated an area of 0.084 sq. km and 0.35 sq. km while the average rate of retreat found to be 7.442 m/y and 22.56 m/y respectively in the period of 1962-2005 (43 years).

Keywords: snout retreat, area vacated, natural hazards, pro-glacial lake, supra-glacial lake.

1. Introduction:

Glaciers form a key natural resource for the Himalayas. A glacier can be described as a moving mass of ice composed of consolidated and re-crystallized ice on land which drifts down via virtue of gravity (www.gsiportal.org.in). These are very vital for global surroundings. They are a major source of natural hazards and also play a key role in global climate change. Furthermore, glaciers are the inimitable resources of fresh water, and critical economic factor for tourism/pilgrims spots (e.g. Gangotri and Badrinath Kedarnath temples). It is the main source in hydro-power production. Glaciers are formed in a suitable climate and topography, in which the rate of precipitation is more than melting of snow and temperature. Widely, it has been categorized into two zones. The first zone is called the accumulation zone whilst the alternative one is referred to as the ablation zone. Those zones are separated through a line that is noted be equilibrium line altitude (ELA). ELA is defined as the mean elevation of a zone where accumulation equivalents ablation throughout a period of twelve months. Sometimes, it is rarely detected as a line at similar elevation throughout the whole width of the glacier pertaining to local climatic and topographic disparities in accumulation and ablation. Consequently, ELA is defined as the mean elevation of the equilibrium line. Snow is any other vital term which consists of ice crystals, liquid water and trapped air in a mixture of shape. After a fresh snowfall, water molecules of snowflakes on ground diffuse from the centres, as a result, the flakes have a tendency to come to be rounded, or spherical. Morphologically, glaciers can be classified as an ice sheet, ice cap. Singh et.al. (2011) suggested that the Ice sheet and ice cap glaciers are shaped once when the underneath geography is completely sheltered through the ice and thereafter the movement of glaciers continue to be unaffected. Paterson, (1994) suggested that valley and cirque glaciers may be taken into consideration as an example of glaciers managed through its topography and the terrain geometry. Bahuguna, (2003) advised that a top

Assessment Of Rock Slope Stability Along Minas Road, Tons Valley, Uttarakhand Himalaya

Gambhir singh chauhan, h.c. Nainwal

Abstract: Slope stability analysis along the Minas road was carried out at 7 locations. Limestone, sandstone and slates are the main rock types. Geotechnical Data for Rock Mass Rating (RMR) were taken from each location for the rock mass classification. The rock samples were also collected for the lab analysis. The stereographic projections of rock joints were plotted for Kinematic analysis and different slope failures (planar and wedge) were identified. Geological cross section of each rock slope was prepared to show the orientation of different sets of joints with respect to the slope face. Finally the Factor of safety (FOS) of each rock slopes were determined.It was found that among the 7 rock slopes 3 falls in good and 4 in fair RMR class. The Kinematic analysis shows that 2 rock slope form planar failure and 5 wedge failures. The Factor of safety analysis depicts that 3 rock slopes have a FOS value above 1 and form stable slopes while 4 rock slopes shows a FOS value near and below 1 which represent partially stable and unstable slopes.

Keywords : Slope stability, Tons valley, Kinematic analysis, Factor of safety, RMR, UCS, Planar failure

1 INTRODUCTION

Slope instability problems are common in hilly terrain mainly along the roads and highways. Rocks in the Himalayan terrain are highly deformed with a number of structural discontinuities. Slopes of an area become unstable either due to natural process or anthropogenic activities. Road cutting causes the steepening of slopes and exposer of more discontinuities along which a slope may fail. Slope stability of an area depends on different properties of rock mass of that area. The Rock mass along a road section can be classified into different RMR classes to analyze the slope stability condition. The FOS analysis of an area is carried out to estimate the stability condition of the slope. For this purpose various numerical methods are used to calculate the FOS of a slope. In this analysis a slope is categorised into stable, partially stable and unstable classes. Slope stability and landslide study along the highways and roads were carried out in past by various researchers like, [1] carried out the Study of landslides in Mandakini valley, Stability analysis of Kaliyasaur landslide along NH-58 [2], Landslide study on the Berinag Munsiyari road, Pithoragarh [3], Cut slope stability analysis in Rudraprayag district of Uttarakhand using CSMR and kinematic analysis [4], Numerical slope stability analysis [5], The study of rockslides /cut slopes and their mitigation measures [6], Rock mass Assessment along the Sutlej river, [7], Assessment of Rock fall hazard along a NH-58 in the Alaknanda Valley using Kinematic analysis [8], Study of slopes along the NH-58 using SMR and kinematic analysis approach [9], Stability analysis of Lakhwar dam reservoir [10], Stability analysis of slope failures along NH-305, India [11], Stability analysis of landslides along Balia Nala, Nainital Uttarakhand [12], Stability analysis of the Pawari landslide, Himachal Pradesh [13], Landslide stability analysis in Rudraprayag and Agastyamuni, Uttarakhand [14], Stability analysis of rock slopes for planar mode of failure [15].Study area lies along Minas road which passes along the Tons valley and connect the pilgrimage, tourist places such as Hanol, Tuni, Harkidoon and various villages of Uttarakhand with the main city. Minas road gets blocked in raining season due to the slope instability problem which cause the interruption in transportation. Slope stability study along the road section is helpful to know the causes of slope failures and their mitigation measures. In present work stability analysis of unstable Rock slopes located along the minas road was carried out (Fig 1).

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2. STUDY AREA

The area of study is located between latitude 30°36'30"N-30°46'0"N and longitude 77°40'0"E-77°49'0"E and lies in the survey of India toposheet no 53F/14 and 53 F/10 along the minas road in the Tons valley, Dehradun district of Uttarakhand (Fig.1). The study area falls in the lesser Himalaya zone and is characterized by the tropical monsoon climate. The major rainfall in the study area occurs from mid-June till early October.

3. GEOLOGICAL SETUP

The present study area is located in the lesser Himalaya covering sedimentary and metamorphic rocks of the Chakrata, Deoban, Mandhali, Chandpur Formations and Bansa limestone. Slate, sandstone and quartzite are the rock types of the Chakrata Formation and limestone is the main rock type of Deoban Formation. The Mandhali and Chandpur Formations are dominantly consists of slate.

Glacier mass loss in the Alaknanda basin, Garhwal Himalaya on a decadal scale

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Abstract

The Himalayan glaciers significantly contribute to the largest river systems like the Indus, Ganga, and the Brahmaputra. The change in glacial area and mass can affect the mountain community and people living in the Indo-Gangetic plain. The present study adopted the geodetic method to estimate the elevation change and mass budget of 61 glaciers in the Alaknanda Basin, using the satellite data of Cartosat-1 (2011, 2014, 2017) and SRTM (2000). Besides, the DEM of 1962 (SOI Toposheet) and 2000 (SRTM) is used to estimate the mass budget of Satopanth (SPG) and Bhagirath Kharak glaciers (BKG). The field debris thickness of SPG (2015-2017) is compared with the elevation change (2000-2017). Further, we have compared the mass loss of the glaciers with their volume. The results suggest the sustained mass loss of 1.85 ± 0.10 Gt out of 33.9 ± 8.8 Gt for 61 glaciers in the basin from 2000-2017. The mass loss of SPG and BKG during 2000-2017 is 0.20 ± 0.02 Gt and 0.24 ± 0.03 Gt, whereas from 1962 to 2000, is 0.083 ± 0.03 Gt and 0.091 ± 0.04 Gt, respectively. The analysis facilitates a better understanding of glacier mass changes in the Alaknanda basin on a multi-decadal scale.

Keywords: "Alaknanda Basin, Debris thickness, Geodetic method, Mass budget, Satopanth Glacier."

1. Introduction

Melting of ice sheets and mountain glaciers worldwide due to climate warming has played a major role in the sea level rise (IPCC 2014). The Himalayan region is known as the third pole or High Mountain Asia (HMA), and situated at the world's highest-altitude. Glaciers in the Himalaya are undergoing mass changes due to varying climatic conditions, and it has significant implications on earth's climate and regional hydrology (Bolch *et al.* 2012, Gardner *et al.* 2013). In the Western and Karakoram Himalayan regions, the glacier meltwater is not much influenced by summer monsoon when compared to the Central and Eastern Himalaya (Immerzeel *et al*., 2010; Bolch *et* al., 2012, Bhambri *et* al 2013). The glacier fluctuation due to rise in temperature and reduced precipitation has affected the dynamics of glaciers in the Himalayan region, i.e., most of the glaciers have endured either retreat or thinning (Kääb *et al.* 2012, Yao *et al.* 2012, Kraaijenbrink *et al.* 2017, Mehta *et al*. 2013). Immerzeel *et al.* 2012, Tawde *et al.* 2017, Maurer *et al.* 2019 These changes have influenced the populace's livelihood and well-being, living in the densely populated Himalayan range (Immerzeel *et al.* 2012, Tawde *et al.* 2017, Maurer *et al.* 2019). Thus, a better assessment of the mass budget will help us model the glacier meltwater runoff and future water resource management (Shean *et* al. 2020).

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Black carbon over a high altitude Central Himalayan Glacier: Variability, transport, and radiative impacts

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ABSTRACT

Ambient equivalent black carbon (BC) measurements spanning from June to October have been carried out over an adjoining location of Satopanth and Bhagirath-Kharak Glaciers (3858m, amsl) of Central Himalaya during the year 2019. Hourly BC varied from 12 ng m^{-3} to 439 ng m^{-3} during the entire period of observation. Monthly averaged BC values showed the highest concentration during June (230.96 ± 85.46 ng m^{-3}) and the lowest in August (118.02 ± 71.63 ng m^{-3}). The decrease in BC during monsoon months is attributed to limited long-range transport and rapid wet scavenging processes. Transport model studies indicate a higher retention time of tracer in Uttarakhand, Punjab, Haryana, and adjacent polluted valley regions with increased biomass burning (BB) incidences. The high rate of BC influx during June, September, and October was attributed to transport from the polluted Indo-Gangetic Plain (IGP) region, wildfires, and vehicular emissions in the valley region. Higher equivalent brown carbon (BrC) influx is linked to BB, especially wood-burning, during intense forest fires at slopes of mountains. Data obtained from limited BC observations during the 2011–19 period showed no significant BC influx change during post-monsoon. The strong correlation between BC mass and BB affirms the dominant role of BB in contributing BC to the Glacier region. Increased TOA forcing induced by surface darkening and BC atmospheric radiative heating indicate an additional warming and possible changes of the natural snow cycle over the glacier depending on the characteristics and extent of debris cover.

1. Introduction

Aerosols modulate the energy budget of the earth-atmosphere system by complex interaction with solar radiation. They play a crucial role in facilitating precipitation by acting as cloud condensation nuclei (CCN). Aerosols modulate cloud behavior by changing cloud microphysics; polluted clouds reflect more radiation causes cloud albedo effect and suppressing precipitation by cloud lifetime effect (Twomey, 1977; Albrecht, 1989). Based on their optical properties, aerosols are classified broadly into scattering and absorbing types. Scattering aerosols cool the earth's surface by reflecting solar radiation, whereas absorbing aerosols heat the atmosphere by absorption processes. BC aerosols are carbonaceous aerosols with maximum absorption potential. BC aerosols alter vertical instability, suppress convection, and cloud cover by tropospheric column warming (Hansen et al., 1997; Ackerman et al., 2000; Koch and Del Genio 2010). BC aerosol's complex interaction with atmosphere and snow is not very well understood (Zhou et al., 2018). Modeling and satellite data-based studies have recently identified that anthropogenic aerosols pose a real threat by increasing tropospheric warming and curtailing surface albedo over the Hindu-Kush Himalayan region (Gautam et al., 2009; Menon et al., 2010; Santra et al., 2019). BC has an inherent ability to absorb the visible-infrared spectrum of solar radiation and heat the surroundings. The life span of BC in the atmosphere is significantly less compared to carbon dioxide. Hence, mitigation or reduction reflects positively in the atmosphere in a shorter time (Takemura and Suzuki, 2019). BC's global warming potential (GWP) is identified next to carbon dioxide (Bond and Sun, 2005). The retreat of glaciers and changes in the equilibrium line of altitude (ELA) is rapidly

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Volume estimation of glaciers in Upper Alaknanda Basin, Garhwal Himalaya using numerical and scaling methods with limited field based data

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Abstract: The ice volume is an important parameter for quantifying fresh water stored in the Himalayan cryosphere. It is an important input to model the glacier dynamics and consequently estimate the future glacier melt contributions to the rise in sea level and changes in the river flows. While there are large uncertainties in the estimates of total ice volume, even less is known about its distribution at the basin scale. In this study, an attempt has been made to assess the volume of glaciers of Upper Alaknanda Basin (UAB), Garhwal Himalaya, using statistical power scaling and slope dependent numerical methods with input from remote sensing data. We have mapped 166 glaciers (area >0.02 km^2) in UAB covering total glacierised area of ~363±12 km^2 using remote sensing data and have used the above mentioned methods to estimate the ice volume. We have checked the consistency of these results with the limited data of estimates of the ice volume of individual glaciers using other methods. We present estimates of the ice volume of Satopanth glacier (SPG) based on previous measurements of the ice thickness using Ground Penetrating Radar (GPR) studies supplemented by more recent observations. The estimated ice volume of SPG is approximately 2.1 km^3. The total glacier volume of UAB is estimated by different methods ranges from 20.5±1.4 to 35.5±2.1 km^3 with an average 26.1±4.5 km^3. We compare this estimate with the estimated ice volume of other Himalayan basins.

Keywords: Glacier thickness, Ice Volume, GPR profiling, Himalayan Glaciers, Upper Alaknanda Basin

INTRODUCTION

The Himalayan cryosphere is a reservoir of fresh water and is referred to as the third pole of the world (Immerzeel *et al.* 2010). The glacier melt water contributes significantly to the river runoff and, along with other components, plays a significant role in the hydrology of the upper basins (Thayyen & Gergan 2010). Glacier inventory shows that there are 9575 glaciers having areal extent of 37,466 km^2 in the Indian Himalayan Region (IHR) (Raina & Srivastava 2008). Glacier extent studies reported the spatial coverage of 22,800 to 25,041 km^2 of Himalayan glaciers excluding Karakoram (Bolch *et al.* 2012; Kulkarni & Karyakarte 2014).

Recent observations reveal that most of the glaciers in the Himalayan region are retreating and losing mass at heterogeneous rates and this trend is expected to continue (Hock *et al.* 2019; Azam *et al.* 2018; Brun *et al.* 2017). Thus, under ongoing climatic conditions, an assessment of glacier volume is essential for water resource management at regional as well as catchment scale.

Recent advancement in remote sensing data and techniques has led the glacier area mapping extensively in high mountainous region (Bolch *et al.* 2012). However, since remote sensing observations do not directly measure the ice thickness, ice volume estimations have to be indirect, based on empirical models (Chen & Ohmura 1990; Bahr *et al.* 1997, 2015). The volume of entire Himalayan-Karakoram glaciers estimated using empirical models from surface data varies from 2955 to 4737 km^3 (Frey *et al.* 2014). In the IHR, glacier mass estimated by scaling methods is reported to be 3600-4400 Gt (Kulkarni & Karyakarte 2014). The high range of variability in the volume estimates is mainly due to the lack of direct field measurements of ice thickness that can be used to choose one empirical method over the other. Only a few studies have been carried out for ice thickness estimation using GPR surveys in the IHR. Dokriani glacier in the central Himalaya, where ice thickness measurement had been done by direct GPR method, has observed thickness varying from 15 to 120 m equivalent to total ice volume of 0.283 km^3 (Gergan *et al.* 1999). The ice thickness of Chhota Shigri glacier was estimated by GPR at five different locations (Azam *et al.* 2012). The cross profiles show that centre-line ice thickness increases from 124 m to 270 m at 4900 meter above sea level (m.a.s.l.). In addition, an attempt to estimate thickness of Satopanth glacier by GPR was also made (Mishra *et al.* 2018); ice thickness at two locations was found in the range of 38-48 m near glacier snout and 90-110 m at the end of ablation zone.

In this work, we use the following empirical models. (i) The slope dependent method proposed by Haeberli & Hoelzle (1995). This assumes that the ice dynamics is in the so called plastic limit. It then yields an empirical formula for the local ice thickness as function of the local slope. In principle, it is valid for a single glacier. (ii) The area-volume scaling law. This is a more global approach and is valid only in a statistical sense, namely for a collection of a large number of glaciers. In this context, it can be physically motivated (Bahr *et al.* 1997, 2015). The scaling law involves several parameters. These vary according to the data sets from which they are estimated. We investigate four such parameter sets (Chen & Ohmura 1990; Bahr *et al.* 1997; Arendt *et al.* 2006 and DeBeer & Sharp 2007).

Other methods, based on surface velocity and slope measurements along with some modelling, to estimate the ice volume of individual glaciers have been developed (Farinotti *et al.* 2009; Huss & Farinotti 2012; Linsbaur *et al.* 2012). Gantayat *et al.* (2014) used such a method to estimate

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Geological and geotechnical studies of landslides located near Ichhari Dam Reservoir on Tons valley, Uttarakhand Himalaya

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Abstract: Geological and geotechnical study of Ichhari and Pathua landslide zones located along the Minas road near the reservoir of Ichhari dam was carried out to delineate the causes of landslide, and to determine the Factor of safety (FOS). Ichhari landslide is a planar slope failure consists of rocks and debris. The Pathua landslide is a circular failure, and it contains debris material. Uniaxial compressive strength (UCS) and triaxial compressive strength (TCS) tests of rock core samples were performed to determine the shear strength (C and ϕ). Sieve analysis of soil and debris material was carried out for grain-size analysis and the direct shear test of debris was used to determine shear strength. Liquid limit test was done for fine material. The results show that UCS and shear strength of rock mass in the Ichhari landslide varies at a large extent due to variation in weathering pattern and deformation of rocks. In the Pathua slide, the coarse-grained material of landslide shows low moisture content and liquid limit due to low proportion of fine material. It reflects that soil cannot remain stable under high water saturation condition. Study of tropical rainfall measuring mission (TRMM) data of monsoon season shows that maximum rainfall in the study area occurred in 2011 and 2013 is about 1420 mm and 1203 mm respectively. The Factor of safety (FOS) of Ichhari rock slide was determined using Limit equilibrium method. The value of FOS of 1.47 was obtained for saturated slope condition. The FOS of circular failure of Pathua slide was identified using the circular failure chart (CFC) method. The FOS value of 0.95, 0.91 and 0.84 were found for dry, 25%, 50% saturated slope conditions respectively. These results show that there are multiple causative factors responsible for landslides. Both landslides are stable under dry condition but become unstable after water saturation during raining season that causes reduction in the shear strength of landslide material.

Keywords: Landslide, Geotechnical study, Reservoir, Factor of safety, Tons valley, Uttarakhand Himalaya

INTRODUCTION

Landslide is a common geomorphic process in the mountainous terrain. Excluding the permafrost regions of the northern India, about 12.6 % part of the country is vulnerable to landslide hazards (GSI 2016). The Indian Himalayan region is prone to about 15 % of the global rainfall induced landslides (Froude & Petley 2018). There are several preparatory and triggering factors responsible for the landslide. Preparatory causal factors such as weathering, erosion works for the long-time duration and make the slope susceptible to movement without intending it. Triggering causal factors are those which initiate movement in slope such as rainfall, earthquake, and excavation on the toe of the slope. Slope failure can be classified into translational and rotational types (Varnes, 1978), which are mainly controlled by cohesion (C), and the angle of internal friction (ϕ) of rock mass. Anthropogenic activities such as road cutting and civil engineering construction have played a major role in increasing frequency and intensity of landslide occurrence. Several landslides occur along the reservoir rim of a dam due to fluctuation in the water level which cause wetting and drying of the slope (Kumar *et al*. 2016). A landslide that occurs along the reservoir rim may create water waves in the reservoir and reduces the water storage capacity of the reservoir. Number of landslide zones are located along the National and State highways of Uttarakhand, due to its complex geology, structures, rainfall, and anthropogenic activities. These landslide zones become active during rainy season and cause interruption in transportation and hardship to the local peoples and tourists/pilgrims.

The detailed study of some individual landslides in the Uttarakhand Himalaya and other parts of India was carried out by various researchers like, landslides in Garhwal Lesser Himalaya (Sati *el al.* 1998), Malpa Rock fall in the Kali valley (Pant & Luirei 1999), study of landslides in Mandakini river valley (Joshi *et al*. 2001), Kaliasaur landslide in the Alaknanda valley (Nainwal & Prasad 2001 and Nainwal 2002), Varunavat Landslide in the Bhagirathi valley (Gupta & Bist 2004), Harmony Landslide (Anbalagan *et al*. 2008), Vyung Landslide (Chaudhary *et al.* 2010), landslide disaster on the Berinag Munsiari road, Pithoragarh (Sarkar & Kanungo 2010), micro-hazard landslide study in Garhwal Lesser Himalaya (Kumar *et al*. 2012), Amiyan landslide (Singh *et al.* 2013), problems of rockslides /cut slopes and their mitigation measures (Naithani *et al.* 2015), Surabhi Resort Landslide, Mussoorie (Gupta *et al.* 2016), Geotechnical characterization and stability evaluation of the hill cut soil slopes along a highway (Sharma *et al.* 2016), stability assessment of slide zones along the Yamunotri pilgrimage route, Lesser Himalayan (Dudeja *et al.* 2017), hazard evaluation of the Pawari landslide zone, Satluj valley, Himachal Pradesh (Kumar *et al.* 2018), study of landslide prone slopes around Rudraprayag and Agastyamuni in the Uttarakhand Himalaya (Pradhan *et al.* 2018), rock slope stability-statistical analysis for plane mode of failure (Raghuvanshi 2019).

Dai *et al.* (2001) observed that lithology and weathering conditions of underlying rocks determine the nature and rate of geomorphic process including landslides. Using past rainfall data, study on occurrences of natural hazards in Alaknanda valley was conducted by Joshi *et al.* (2006). Assessment of landslide in the Bhagirathi valley due to 2013 flood was performed by Bhambri *et al.* (2017). These studies observed that rainfall threshold varies from one region to the

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Observations of black carbon and albedo over a Central Himalayan Glacier (Satopanth): Preliminary results

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ABSTRACT

Simultaneous measurements of ambient atmospheric black carbon (BC) mass concentrations and radiative fluxes were carried out over Satopanth glacier in the central Himalayas from September 22 to October 2, 2016, as a part of a glacier campaign experiment. The daily mean atmospheric BC concentrations varied between 165 ± 20–263 ± 32 ng m^{-3} with a mean of 199 ± 54 ng m^{-3} during the observational period. The measured average surface albedo was found to be 0.24 ± 0.11 during the entire period of observation. Spectral albedo from Moderate Resolution Imaging Spectroradiometer - Bidirectional Reflectance Distribution Function (MODIS-BRDF) satellite observation and net radiometer derived glacier albedo was found to be in good agreement with a correlation of 0.64 over the region. Concentration weighted trajectory analysis (CWT) over the site indicates a 70% BC transport from the Indo-Gangetic plain, Pakistan, and the Middle East region. BC radiative forcing was estimated using an optical model along with a radiative transfer model. An average BC direct radiative forcing of −5.4 ± 0.25 W m^{-2} and 2.4 ± 0.19 W m^{-2} was found respectively in the surface and at the top of the atmosphere (TOA) during the experimental period. The estimated average BC induced heating rate was found to be 0.33 ± 0.04 K day^{-1}over the region.

1. Introduction

Himalayan glaciers are the primary source of freshwater for the northern Indian rivers, providing approximately 8.6 million cubic meters of water annually (Khan et al., 2017; Dyurgerov and Meier, 1997). Many scientific studies have reported abnormal retreat of glaciers over the Himalayas in recent decades (Bahuguna et al., 2014; Shekhar et al., 2017; Nainwal et al., 2007). The mass balance studies have shown a cumulative negative surface mass balance in all observed glaciers of the Himalaya with a decreasing trend from northwest to northeast Himalayan region (Shekhar et al., 2017). Earth's surface energy budget and radiative balance are highly influenced by snow albedo (Groisman 1994). The hydro-climatic impact of BC by direct, indirect, and snow darkening effect are major concerns in regional climate impact assessment (Lenton and Vaughan, 2009; Kang et al., 2019). Light absorbing impurities (LAI) such as black carbon (BC) and increased greenhouse gas emissions can alter the surface temperature and induce melting of Glaciers (Flanner et al., 2007; Menon et al., 2010; Bollasina et al., 2011; Niu et al., 2020). BC deposition on fresh snow vastly decreases its albedo, resulting in warming at the top of the atmosphere and contributes to global and regional climate change (Ramanathan and Carmichael, 2008; Jacobson 2001; Painter et al., 2007). The rapid melting of Himalayan glaciers in recent years is primarily attributed to snow darkening and increased direct radiative forcing by absorbing aerosols such as BC (Yasunari et al., 2013; Gul et al., 2018; Niu et al., 2020). It is identified that a moderate concentration of aerosol cover with thickness up to 2 mm has maximum effects on glacier melting, thickness above 2 mm works as an insulator and stops further melting, and has no real importance (Dragosics et al., 2016). Satellite-based and modeling studies indicated a greater gradient in heating over the Himalayan region during the pre-monsoon season than other seasons (Gautam et al., 2009). Direct radiative forcing simulations of carbonaceous aerosols

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Short Communication

Black carbon over a central Himalayan Glacier (Satopanth): Pathways and direct radiative impacts

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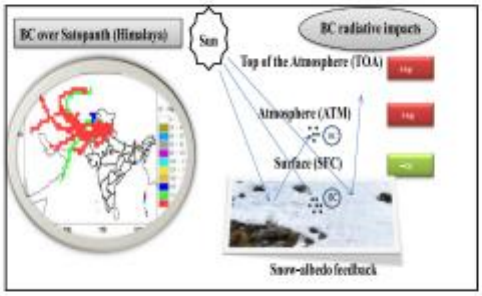
HIGHLIGHTS

- Black carbon (BC) observations were carried out over Satopanth Glacier.
- BC Mass varied between 28 and 287 ngm^{-3}.
- BC pathways has been quantitatively estimated.
- BC induced snow albedo impacts estimated.

GRAPHICAL ABSTRACT



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ABSTRACT

Continuous measurement of Black Carbon (BC) concentration was carried out during May–October 2018 periods over Satopanth Glacier in the central Himalayas. BC concentrations varied between 28 and 287 ngm^{-3} on different days during the observational period. High concentration of BC was observed in the month of May (monthly mean of 221 ± 79 ngm^{-3}), and a lower concentration was observed in August (monthly mean of 92 ± 58 ngm^{-3}). Biomass burning was found to contribute up to 58% of BC mass over the region, with lower contribution during June and higher during the month of May. Compensation parameter (K) values were found to vary between −0.005 and 0.005 in different months, asserting the presence of aged BC in June to October months and relatively fresh BC in the month of May. Concentration weighted trajectory (CWT) analysis showed that the air mass from Indo Gangetic Plains (IGP) was responsible for the majority of transported BC in July & August months (up to 65%) and partially in September (up to 40%). However, the transport from Middle East and far northwestern regions was found to be the major contributor to BC concentrations in other months. The estimated BC direct radiative forcing was found to induce 4.5 to 7.6 Wm^{-2} reduction of radiation at the surface (SFC) and the forcing was +2.3 to +3.5 Wm^{-2} at the Top of the Atmosphere (TOA). The BC induced atmospheric heating rates were found to be up to 0.35 k day^{-1} over the region. The sensitivity of snow albedo to radiative forcing was studied, and it is found that BC albedo changes tend to decrease albedo with an increase in BC-snow deposition, leading to a decrease in atmospheric absorption.

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Research papers

Tracing the isotopic signatures of cryospheric water and establishing the altitude effect in Central Himalayas: A tool for cryospheric water partitioning

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ABSTRACT

This study focuses on the isotopic characterization of cryospheric water and quantification of different components contributing to Alaknanda River (major tributary of the Ganges River system) at its place of origin near snout of the Satopanth Glacier. A detailed understanding of various sources/flow components contributing to the river is useful for water resource management under changing climate scenario and helpful in risk assessment due to natural hazards in the headwater catchments, Extensive fieldwork was conducted, and water samples were collected from the river, snow, glacial ice, rain, lakes, and supraglacial channels of Satopanth Glacier Basin during the ablation period of 2017 and analysed for $\delta^{18}O$, $\delta^{2}H$, and ^{3}H along with electrical conductivity. The results helped to establish the spatio-temporal and altitudinal variability in isotopic signatures of rain, snow, and ice in Satopanth Glacier Basin. The altitudinal effect in $\delta^{18}O$ of pre-monsoon and monsoon rainfall is −0.13‰ and −0.41‰ per 100 m rise in elevation, respectively. Snow samples show depleting isotopic trend with an altitude effect of −0.43‰ in $\delta^{18}O$ per 100 m rise in altitude. However, snowpack samples show an enrichment with time indicating post-depositional isotopic fractionation. The contrasting isotopic gradient in debris covered and non-debris covered ice are −0.9‰ and +3.4‰ per 100 m rise in elevation, respectively. These results divulge the spatial as well as temporal variation in cryospheric waters and these variations are used to derive the isotopic signatures of snow melt, glacier melt, and rain water. The results of hydrograph separation show that the snow melt, ice melt and rain water contribute about 33%, 49% and 18% respectively, to the discharge of Alaknanda River during the ablation period. Tracer based hydrograph separation indicates that the snow melt contribution dominates in river discharge during the initial ablation period. River discharge is a mixture of snow melt, glacier melt and rain water during July and August, while there is a dominance of glacier melt during end of the ablation period. The results of the present study highlight the importance of accounting the spatial and temporal variability in tracer signatures of cryospheric water for quantifying the contributions of snow and ice melt in a river originating from glacerised area.

1. Introduction

The cryosphere contains about 69% of the global freshwater sources and plays an essential role in maintaining the hydrological cycle (Gleick, 1996). However, the rapid retreat and mass loss of alpine glaciers have been reported by many and projected to continue throughout the

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ORIGINAL PAPER

Source characterization of suspended sediments transported from debris-covered Chorabari Glacier in Central Himalaya, India

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Abstract
Huge voluminous debris supplies that are transported because of the extreme rainfall events and glacial lake outburst floods has resulted in the accumulation of excessive sediments, thereby depleting the capacities of desilting chambers in the downstream hydropower projects. Therefore, the present article is focused on understanding the textural facies, bulk mineralogical composition, and environmental magnetic properties of suspended sediments to highlight the transport characteristics within the Chorabari glacierized catchment. Sediment representatives were analyzed by the X-Ray diffraction (XRD) and routine mineral magnetic parameters for the ablation seasons (June–September) of 2009, 2011, and 2012. Results reveal that monthly and seasonal fluctuations in the runoff magnitude exhibit significant influence on the linked-conduit system resulting in the enlargement of transport pathways. Flemming's (sand/silt/clay) trigon reflects the dominance of silty sand facies with little clay content implying that the influence of hydrometeorological conditions transport the glacial debris to the downstream areas. Proglacial meltwater stream transported more than 60% of the total weight percentages of hard mineral aggregates such as quartz and feldspar fractions indicating high intensity of physical disaggregation that occurs at the high-altitude environment. Environmental magnetic properties reflect unimodal source showing combined signatures of weak ferrimagnetic and high nonmagnetic minerals. Analysis of Pearson correlation coefficient (PCC) revealed heterogeneity in the production and transportation of silt- and sand-sized sediments for each ablation season. These findings conclude that considerable percentages of fine glacial debris gets entrained into the linked-conduits from where they get exported as suspended sediments along with glacier meltwater through the subglacial opening.

Keywords Melt runoff magnitude · Textural facies · Supraglacial debris · Physical weathering · Indian Himalaya

Introduction

The Indian Himalayan Region (IHR) is covered with large areas of snowfield and glaciers that provide freshwater supplies to densely populated downstream areas in the Indo-Gangetic plains (Immerzeel et al. 2010). The climatic regime and debris cover exert a strong influence on the glacier health resulting in the generation of melt runoff during the recent negative mass balance period (Shukla and Qadir 2016; Azam et al. 2018). Studies characterizing glacial debris and its transport mechanism were earlier documented by Boulton (1978) and Boulton and Eyles (1979). They inferred that the sediment production and its transport materialized through active subglacial zones with little modification occurring in the passive supraglacial zones. However, this concept may not hold true for the high-altitude valley glaciers of the Karakoram and Himalayan region where the supraglacial debris cover is relatively abundant (Gutiérrez 2005), and erosional processes are particularly active on the glacier surface (Benn et al. 2012; Kirkbride and Deline 2013). These glaciers produce a large quantity of supraglacial debris by the glacial processes such as crushing, weathering, and rock fracturing of various geomorphic features depending upon the geological setting (Ballantyne and Benn 1994; van Woerkom et al. 2019). Similarly, the non-glacial processes such as the mass movement of bordering rock walls leading to rock avalanches

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Geochemistry of Granites from Chail Group of Garhwal Region, Lesser Himalaya, NW India

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Abstract: Paleoproterozoic granites are well exposed in the Chail group of Garhwal region, Lesser Himalaya crystalline sequences (LCHS). These granites are less studied in terms of geochemical classification and tectonic settings. In the present work, we carried out the geochemical analysis of granites of the Chail group from the Chirbatiya-Khal and Ghuttu areas. All the samples have high SiO_2 (73.24–79.1 wt %), Al_2O_3 (11.2–12.95 wt %), K_2O (3.8–5.9 wt %) and low P_2O_5 (0.11–0.24 wt %), CaO (0.21–1.02 wt %), and Na_2O (2.2-3.03 wt %; exceptionally low in one sample, that is 0.009 wt %) contents. The A/CNK values for the samples are range from 1.19 to 2.91, characteristic of S-type granites. REE patterns for these granites are moderately fractionated with an average $(La/Yb)_N$ ~ 8.21 and europium anomaly (Eu/Eu*) ~ 0.15. The tectonic settings of the studied granite suggest that they are formed in syn-collision tectonic environments.

Keywords: Granites, Himalaya, geochemistry, Paleoproterozoic, Garhwal Himalaya

Introduction

Granites are the most abundant rocks in the Earth's crust. Therefore, understanding the origin of the Earth requires a thorough understanding of the evolution and reworking of the upper continental crust. Granites have a vast range of mineral composition, geochemistry, petrogenesis, and tectonics, as evidenced by extensive studies undertaken around the world. In general, it is now believed that a significant number of granites, such as those seen along active continental margins, can result from fractional crystallization of basaltic magma. In addition, under variable temperature and pressure conditions, partial melting of crustal protoliths during regional metamorphism in orogenic collisions also creates varied granites.

This paper aims to present the whole-rock geochemistry from Chail group granites in the Garhwal region of LHCS. We suggest that these Paleoproterozoic granites are S-type in origin and formed in syn-collision tectonic settings, based on their geochemical characteristics.

Geological background

In the 2400 km long Himalayan belt, four primary tectonic zones accrete from south to north: 1) Sub-Himalaya (SH); 2) Lesser Himalaya (LH); 3) Higher Himalayan Crystalline (HHC); and 4) Tethyan Himalaya (TH) (Heim & Gansser, 1975). (Fig. 1a). The SH, which is made up of Miocene to Pleistocene molasses and Himalayan sediments, thrusts over the Indo-Gangetic

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Article

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Estimation of ice ablation on a debris-covered glacier from vertical debris-temperature profiles

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Abstract

A supraglacial debris layer controls energy transfer to the ice surface and moderates ice ablation on debris-covered glaciers. Measurements of vertical temperature profiles within the debris enables the estimation of thermal diffusivities and sub-debris ablation rates. We have measured the debris-layer temperature profiles at 16 locations on Satopanth Glacier (central Himalaya) during the ablation seasons of 2016 and 2017. Debris temperature profile data are typically analysed using a finite-difference method, assuming that the debris layer is a homogeneous one-dimensional thermal conductor. We introduce three more methods for analysing such data that approximate the debris layer as either a single or a two-layered conductor. We analyse the performance of all four methods using synthetic experiments and by comparing the estimated ablation rates with in situ glaciological observations. Our analysis shows that the temperature measurements obtained at equispaced sensors and analysed with a two-layered model improve the accuracy of the estimated thermal diffusivity and sub-debris ablation rate. The accuracy of the ablation rate estimates is comparable to that of the in situ observations. We argue that measuring the temperature profile is a convenient and reliable method to estimate seasonal to sub-seasonal variations of ablation rates in the thickly debris-covered parts of glaciers.

1. Introduction

Glaciers in the Hindu-Kush Karakoram Himalaya (HKKH) constitute an important freshwater reserve for downstream populations (Azam and others, 2021). The discharge of meltwater is affected by ice ablation rates. About 11% of the glacierised area in HKKH has been estimated to be covered by a layer of rock debris (Herreid and Pellicciotti, 2020). Observations and physical theory suggest that a thin cover of debris can enhance ice ablation rates, while a cover of more than a few centimetres debris thickness can reduce ablation by insulating the ice from solar and atmospheric energy fluxes (Østrem, 1959). Therefore, understanding the recent past or predicting the future of HKKH glaciers requires an accurate understanding of the effects of dynamical supraglacial debris cover on ablation (e.g., Banerjee and Shankar, 2013; Anderson and Anderson, 2016; Banerjee, 2017; Ferguson and Vieli, 2020).

The influence of supraglacial debris on ablation depends on its thickness and thermal properties (Mihalcea and others, 2006; Reid and others, 2012; Fyffe and others, 2020). While field observations of debris properties in HKKH are scarce (Conway and Rasmussen, 2000; Nicholson and Benn, 2013; Rounce and others, 2015; Chand and Kayastha, 2018; Rowan and others, 2021), they indicate that debris properties vary within and between glaciers at a range of scales, and through time (Mihalcea and others, 2008; Nicholson and others, 2018; Shah and others, 2019). Although the physical theory is understood, the actual variability of the debris layer properties is not currently well characterised, and the effects on ablation are poorly constrained (Nicholson and others, 2018). This results in considerable uncertainty in many glaciological applications, such as satellite-based debris-thickness estimation (e.g., Mihalcea and others, 2008; Foster and others, 2012; Schauwecker and others, 2015) and glacio-hydrological modelling (e.g., Fujita and Sakai, 2014; Hagg and others, 2018; Zhang and others, 2019; Steiner and others, 2021).

It is generally accepted that the global population of glaciers is undersampled (Mernild and others, 2013) due to the logistical challenges associated with fieldwork. HKKH has become known colloquially as the 'third pole' due to its significance in the global cryosphere (Wester and others, 2019), yet, direct measurements of surface ablation have been reported for fewer than 20 debris-covered glaciers in this region (Winter-Billington and others, 2020). Expanding the network of on-site monitoring stations to include a greater number of debris-covered glaciers in HKKH, and sampling from a wider range of geographies (covering a wider range of elevations, e.g., Wang and others, 2019) is necessary to reduce the uncertainties associated with predictions of glacier change.

The glaciological method of monitoring a network of stakes is generally considered to be the most accurate method to measure the surface ablation on debris-covered glaciers (Cogley and others, 2010). This is a labour-intensive method (Kaser and others, 2003). From our direct experience (Shah and others, 2019), the logistical challenges and human resource requirements for performing sub-seasonal glaciological mass-balance measurement

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Comparative assessment of two neighbouring glaciers (Raj Bank and Kosa), Dhauliganga Basin, central Himalaya, India, since 1962 to 2019

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We examined the two neighbouring Raj Bank and Kosa glaciers of the upper Dhauliganga catchment of Uttarakhand, central Himalaya, India, to assess their variability towards climate change. We performed the analysis of multiple satellite images for the period of 1962–2019 and field-based GNSS data obtained during 2018–2019. Length change, area change, debris cover area, and snowline altitude (SLA) were obtained using that. During the last 57 years (1962–2019), the Raj Bank and Kosa glaciers lost 2.43% (0.32 km^2 or 0.006 km^2 a^{-1}) and 4.54% (0.45 km^2 or 0.008 km^2 a^{-1}) area; and for the same time span, their frontal retreat was estimated 639.39 m (11.22 m a^{-1}) and 206.71 m (3.69 m a^{-1}), respectively. The study also depicts that from 1968 to 2019, the Raj Bank glacier shows a significant increase in the debris cover area of 4.41%, while in the Kosa glacier, it was 4.08% only. Between 1968 and 2017, the SLA of the Raj Bank and Kosa glaciers shifted on an average by 82 and 71 m upwards, respectively. Loss in glacial area, enhanced debris cover area, and shift in SLA are the indicators of ice volume loss under the present climatic scenario.

Keywords. Himalayan glaciers; DGPS; debris cover; climate change; snowline altitude.

1. Introduction

Himalayan glaciers form one of the largest ice concentrations outside the polar regions, with an areal extent of >40,000 km^2 in the entire Himalaya, including Karakoram (Bolch *et al.* 2012). The meltwater streams that emerge from the Himalayas help to sustain >750 million people and the economy of the surrounding countries by providing water for irrigation, hydropower, drinking, sanitation, and manufacturing (Immerzeel *et al.* 2010; Pritchard 2017). The Earth's average temperature has increased by 0.6±0.2°C during the 20th century (IPCC 2007), resulting in shrinkage of most of the glaciers and other cryospheric components all around the world, including the Himalaya (Mayewski and Jeschke 1979; Bahuguna *et al.* 2007; Bhambri *et al.* 2011; Sorg *et al.* 2012; Basnett *et al.* 2013; Kraaijenbrink *et al.* 2017). Various studies depict that the Himalayan glaciers have been losing mass since the end of the Little Ice Age (LIA) (Vohra 1981; Dobhal *et al.* 2004; Kulkarni

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Luminescence chronology of Late Quaternary palaeo-lake deposits from the Upper Alaknanda Basin, Uttarakhand, India: Implication to palaeoclimate and depositional settings

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ABSTRACT

Lakes downstream of the glaciers receive glacial meltwater and sediment supply resulting in formation of thick succession of lacustrine deposits. In this work, we have identified one such palaeo-lake deposit in the Upper Alaknanda Basin, close to Badrinath town. The sediments are of lacustrine origin; however the continuity is broken by intermittent fluvial deposits, which indicate changes in the depositional environment. We used Optically Stimulated Luminescence (OSL) dating to develop a robust chronology of the palaeo-lake deposit. Grain size analyses of sediments were carried out to understand the depositional environment, and morphometric analysis of the valley was conducted to obtained clues about the neotectonic activities in the region. The OSL ages show that the deposition of the lake sediments occurred between 21.6 ± 4.7 ka to 10.5 ± 1.4 ka. Two phases of paleo-lake deposit and subsequent outburst is established from the OSL age, grain size distribution and on the basis of field observations. The high sedimentation rate in the upper part of the deposit indicates an increase in the monsoonal rainfall and glacial retreat post Younger Dryas event. The colder periods are represented by varves and rhythmites, while the warmer periods are represented by thick laminated sand. This study indicates that the glaciers in the Upper Alakanada Basin responded to the fluctuations in the palaeo-climate.

1. Introduction

The Indian Summer Monsoon (ISM) is the key component of the tropical climate system, which is produced by the differential heating of the land and sea surface (Holton and Staley, 1973; Webster et al., 1998) and/or by the heating in the intertropical convergence zone (ITCZ) (Hoskins and Rodwell, 1995; Chao and Chen, 2001). The monsoon variability on 10^3–10^5 year scale is controlled by several factors such as incoming solar radiation, inter hemispheric heat transport and high latitude glacial and interglacial boundary condition (Clemens and Prell, 1991; Prell and Kutzbach, 1992; Juyal et al., 2009). The short term climatic fluctuations are independent of changes in insolation but are controlled by oceanic thermohaline circulation, particularly in monsoon dominated region (Sirocko et al., 1993, 1996; Heusser and Sirocko, 1997; Juyal et al., 2009). These climatic fluctuations also impact on Himalayan glaciers because of interrelationship between climate and glacier. During Late Quaternary period, the extent of valley glaciers in the Himalayan range has been significantly modified. Imprints of these oscillations are preserved as glacial landforms in different segments of the Himalaya (Scherler et al., 2010; Dortch et al., 2010; Owen et al., 1997, 2001, 2002, 2006; Sharma and Owen, 1996; Taylor and Mitchell, 2000; Dortch et al., 2013; Barnard et al., 2004; Pant et al., 2006;

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ORIGINAL PAPER

A comprehensive and quantitative assessment of Raunthi Gad flash flood, Rishi Ganga catchment, central Himalaya, Uttarakhand, India

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Abstract

On 7th February 2021, a catastrophic flash flood occurred in Raunthi Gad, Rishi Ganga catchment of Dhualiganga Basin. It caused the death of around 200 people and devastated the hydropower projects and other associated infrastructure in the downstream areas of the basin. While the extent of damage and devastation in the downstream region around Rini and Tapovan has been extensively reported, the reconstruction of the event has still not been definitively established. Based on an analysis of the data reported in previous papers and our field and remote-sensing data, we present a detailed reconstruction of the events that occurred in Raunthi Gad that morning. Our analysis supports previous reports that the basic cause was that a portion of the hanging glacier located at Raunthi peak (5600 m asl) along with a large amount of rock fell and hit the Raunthi valley at about 1.5 km downstream of the current snout of Raunthi glacier at an elevation of around 3800 m asl. We present evidence, supported by previous data of transient ponding in the region between the impact zone and the confluence of Raunthi Gad and Rishi Ganga. We estimate the flood volume at Rini to be around 10 MCM and the volume of water available in the valley in the form of ice and snow to be around 6 MCM. We argue that this deficit can be accounted for by the debris volume. The material gained around 8×10^{14} J of energy during the initial slide whereas around 1.5×10^{14} J is required to melt the ice and snow.

Keywords Flash flood · Disaster · Hanging glacier · Extreme events · Central Himalaya

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Impact of environment and LULC changes on groundwater resources in the Soan Basin, western Himalaya

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Abstract The present study assesses the environmental and Land Use Landcover (LULC) changes in the Soan Basin, western Himalaya between 1999 and 2015 and their impacts on groundwater quality and static water level (SWL). An increase in the area of agricultural land (19%), settlement (~300%), and dense forest (25%) at the expense of open forest and waste cum grazing land was observed subsequently since the year 1999. SWL was lowered in the basin between 1999 and 2013 due to less groundwater recharge with decreased permeable surfaces and decreased rainfall, except in a few locations in the valley fill region plausibly due to the secondary recharge through seepages, infiltration of irrigational wastewater, and waterlogging in the agricultural fields. A continuous lowering of SWL after 2015, even after increasing the rain amount significantly, indicates overexploitation of groundwater in the region. Enhanced use of fertilizers has resulted in an increased concentration of Na^+ and Cl^- ions in groundwater. The results are further substantiated by comparing the hydrochemical data for the years 1999 and 2015, which again indicate the high concentration of Na^+ and Cl^- ions due to waterlogging. From 1999 to 2015, nitrate (average 12.8 mg/l to 16 mg/l) and fluoride concentration (average 0.3 to 0.9) have also increased because of the excessive use of fertilizers in the agricultural fields. The increasing trend of nitrate concentrations in water in successive years since 1994 supports the changes observed in an agricultural pattern in LULC maps for the years 1999, 2009, and 2015. The results divulge that the groundwater quality of the basin has been deteriorating due to an increase in agricultural practices and demands for appropriate water management practices.

Keywords LULC · Groundwater · Static water level · Soan Basin · Himalaya

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Introduction

Water is an essential natural resource for thriving life on the earth. It regulates biochemical mechanisms and contains numerous essential nutrients for human

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RESEARCH ARTICLE

WILEY

Palaeoproterozoic S-type granites from Garhwal Himalaya, NW India: Geochemistry, Sm–Nd isotope systematics and tectonic implications

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A combined geochemical and Sm–Nd isotopic study on the Palaeoproterozoic (1,845 Ma) granites of the Lesser Himalayan Crystalline Sequence (LHCS) in the Garhwal region of NW India has been done in the present study. These granite samples are characterized by high silica, alumina, and potash and belong to a peraluminous to strongly peraluminous series, having molar A/CNK values of 1.01 to 2.4. The low P_2O_5 contents and its negative correlation with SiO_2 presiding out that the granites have S-type affinity, also supported by various classification diagrams (ACF; SiO_2 vs. P_2O_5, $Na_2O + K_2O$-CaO, and Th). The concentration of trace elements Ba, Sr, Nb, and Ti are low, and Rb, Th, U, and Pb are found to be high. The granites have low total rare earth elements contents of 56.19–229.16 ppm with enrichment in Light rare earth elements (LREE) ($[La/Yb]_N = 1.61–15.08$) and negative europium anomaly ($Eu/Eu^* = 0.12–0.31$). Sm–Nd isotope studies were also performed for three granite samples. Estimated model ages as 2.5–2.7 Ga, indicates the contribution of the Archean crustal substrate as their protolith source. Therefore, we assume that the melting of metasedimentary rocks with Archean protolith can form these peraluminous granites in an accretional–collisional event, during the Palaeoproterozoic on the western flank of the Columbia supercontinent.

KEYWORDS
Columbia supercontinent, Himalaya, lesser Garhwal Himalaya, Palaeoproterozoic, S-type granite

1 | INTRODUCTION

Granites are the most abundant rocks found in the Earth's upper crust (Bonin, 2007; Brown, 2013). The evolution and reworking of the upper continental crust are of great significance to understand the formation of the Earth (Hawkesworth & Kemp, 2006). A vast body of literature is available on granites, which reveals its diverse mineral composition, geochemistry, petrogenesis, and tectonics. There is a wide consensus in the literature that a substantial number of granites can originate from fractional crystallization of basaltic magma, like those at active continental margins (Ulmer, Kaegi, & Müntener, 2018). Partial melting of crustal protoliths during regional metamorphism in orogenic collisions also produces various granites under different temperature and pressure conditions (Brown, 2010; Clemens, 2012; Collins, Huang, & Jiang, 2016).

Partial melting of supracrustal or sedimentary rocks can produce strongly peraluminous (SP) granite, classified as 'S-type' granites (Chappell & White, 1974). The S-type granites are frequent in the orogenic belts (Chappell & White, 1992; Li et al., 2021 and references therein). However, the production of S-type granites entails the deposition and subsequent high-temperature metamorphism of sedimentary rocks, which is crucial to understand heat flow in the orogenic

Journal of Glaciology

Glacier inventory and glacier changes (1994–2020) in the Upper Alaknanda Basin, Central Himalaya

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Article

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Central Himalaya; climate change; debris-covered glaciers; glacier changes; glacier inventory

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Abstract

Himalayan glaciers have been shrinking and losing mass rapidly since 1970s with an enhanced rate after 2000. The shrinkage is, however, quite heterogeneous and it is important to document individual glacier characteristics and their changes at the basin scale. We present an updated glacier inventory of the Upper Alaknanda Basin (UAB), Central Himalaya for the year 2020 and report area, debris cover and length changes for the periods 1994–2006 and 2006–2020 based on remote-sensing data. We identified 198 glaciers, comprising an area of 354.6 ± 8.5 km^2, and classified them according to their size and morphology. The glaciers of the basin lost 4.2 ± 2.9% (0.16 ± 0.11% a^{-1}) of their frontal area (from 368.6 ± 9.2 to 353.0 ± 5.3 km^2) from 1994 to 2020. The average retreat rate was higher in the period 2006–2020 (13.3 ± 1.8 m a^{-1}) in comparison to 1994–2006 (9.3 ± 1.9 m a^{-1}). However, the area change rate was similar for the two periods (0.14 ± 0.27% a^{-1} for 1994–2006 and 0.16 ± 0.19% a^{-1} for 2006–2020). The debris-covered area has increased by 13.4 ± 4.4% from 1994 to 2020. A comparison with previous studies in UAB indicates consistent area loss of ~0.15% a^{-1} since the 1960s.

1. Introduction

Himalayan glaciers are shrinking and losing mass at rates comparable to the other regions of the globe (Bolch and others, 2012; Azam and others, 2018; Hock and others, 2019; Hugonnet and others, 2021). The ice loss has clearly increased after 2000 which can mainly be attributed to the current phase of accelerated atmospheric warming in the region (Sakai and Fujita, 2017; Bolch and others, 2019; King and others, 2019; Maurer and others, 2019; Bhattacharya and others, 2021). Recent projections indicate that, depending on the climate scenario, Himalayan glaciers will lose between 30 and 60% of their current mass by the end of the 21st century (Kraaijenbrink and others, 2017; Rounce and others, 2020). This will adversely affect the run-off in the major river systems of High Mountain Asia (Bolch, 2017; Immerzeel and others, 2020; Azam and others, 2021), particularly during periods and years with low precipitation (Pritchard, 2019).

Remote-sensing and field-based measurements indicate that the glacier changes are variable throughout the Himalaya (Scherler and others, 2011; Kulkarni and Karyakarte, 2014; Azam and others, 2018). The general behaviour of the glaciers is driven by climate, primarily by temperature and precipitation (Oerlemans and others, 1998; Oerlemans, 2005). However, the individual glacier response to the climatic forcing is strongly controlled by non-climatic factors determined by topography and the extent of debris cover (Salerno and others, 2017; Bush and Bishop, 2018). Consequently, two neighbouring basins that experience a similar regional climate could respond quite differently to climate forcing due to differences in the topographic settings (Garg and others, 2017). It is therefore important to assess the influence of climatic and topographic parameters on the glacier changes at basin scale. In this paper, we concentrate on the Upper Alaknanda Basin (UAB) in the Central Himalaya where such investigations are limited and no detailed up to date glacier inventory and estimates of glacier area change exist. A basin scale glacier inventory is available for the year 2006 and area changes were estimated for the period between 1968 and 2006 (Bhambri and others, 2011*a*). The present study focuses on the period from 2006 onwards. The previous work done in the UAB is reviewed below.

Bhambri and others (2011*a*) generated a glacier inventory of 83 glaciers in the basin for the year 2006 and reported an area loss of 5.7 ± 2.7% (0.14 ± 0.06% a^{-1}) from 1968 to 2006. Surface elevation changes of glaciers of UAB have been recently reported from 2000 to 2014 (Bandyopadhyay and others, 2019) and for the period 2000–2017 by Remya and others (2020). Both studies indicate an almost similar mean surface lowering, 0.37 m a^{-1} (2000–2014) and 0.33 m a^{-1} (2000–2017). Based on simple models validated with limited field data, the ice volume of the basin has been estimated to be 26.4 km^3 for the year 2016 (Mishra and others, 2021).

There have been several studies of the larger glaciers in the basin. Field studies on Satopanth and Bhagirath Kharak glaciers by Nainwal and others (2007) report three phases of glaciation in the valley during late quaternary period. Nainwal and others (2008) have

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8000-year monsoonal record from Himalaya revealing reinforcement of tropical and global climate systems since mid-Holocene

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We provide the first continuous Indian Summer Monsoon (ISM) climate record for the higher Himalayas (Kedarnath, India) by analyzing a ^{14}C-dated peat sequence covering the last ~8000 years, with ~50 years temporal resolution. The ISM variability inferred using various proxies reveal striking similarity with the Greenland ice core (GISP2) temperature record and rapid denitrification changes recorded in the sediments off Peru. The Kedarnath record provides compelling evidence for a reorganization of the global climate system taking place at ~5.5 ka BP possibly after sea level stabilization and the advent of inter-annual climate variability governed by the modern ENSO phenomenon. The ISM record also captures warm-wet and cold-dry conditions during the Medieval Climate Anomaly and Little Ice Age, respectively.

The Himalaya is the tallest tectonically-uplifted mountain range in the Indo-Pakistan-China region, currently supporting ~15% of the world's population[1]. Several past human civilizations have originated, flourished, and disappeared along the flow paths of major Himalayan river systems, including the Indus-Saraswati, and Ganga-Yamuna-Brahmaputra. Precipitation associated with the Indian Summer Monsoon, melting of glaciers, and sub-surface (ground) aquifers collectively ensure the availability of water in these river systems. Additionally, high-altitude regions of Himalaya also receive rainfall induced by westerly winds during late winter and spring seasons. In the scenario of global warming, the duration of monsoonal-rainfall is anticipated to decrease but the frequency of extreme rainfall events may increase[2]. The concurrent precipitation trends appear to be supportive of such a case[3]. For example, recent rainfall events, such as in 2013 (mid-June) when massive flash floods caused colossal damage to human-life and infrastructure worth ~$3 billion[4], indicate emergence of such a scenario. Recent studies strongly indicate that a above normal monsoon year is likely to be punctuated with high rainfall events[3,5]. Reconstruction of high-resolution monsoonal variability spanning the Holocene is required to better understand the changing rainfall patterns amidst anthropogenic climate change[6]. The Kedarnath area in the Garhwal Himalaya could serve as an excellent locale for recovering such paleo-records. As the Kedarnath area lies over the northern limits of Inter Tropical Convergence Zone (ITCZ), it is expected to capture subtle changes in the ISM variability.

To date, the majority of the ISM records spanning the Holocene are from Arabian Sea sediments, cave deposits from peninsular India and lacustrine/peat sequences from central and north-western India[7–17]. Retrieving high-resolution monsoonal variability from terrestrial geological records is complicated due to several reasons such as regional influences masking the climatic signal, variable proxy response, and chronological uncertainties. Nonetheless, a few paleo-monsoonal records covering the Holocene have recently been reconstructed from the northwest Himalaya[13,15,18,19]. A globally inter-comparable ISM record depicting Holocene climate variability, however, remains elusive. Monsoon climate experts and modelers underscore the importance of reliable proxy-records dating back to ~6 ka BP when sea levels stablized globally[20]. These records can be exploited to ascertain natural climate variability and primary operative forcing factors.

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Pattern of Holocene glaciation in the monsoon-dominated Kosa Valley, central Himalaya, Uttarakhand, India

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ABSTRACT

Reconstruction based on the geomorphology, lateral moraine stratigraphy, and limited optical chronology indicate that the monsoon-dominated Kosa Valley experienced four glacial advances during the late glacial to late Holocene. The oldest and most extensive glaciation, which is termed as Raj Bank Stage-1 (RBS-1), is represented by the degraded moraine ridge. This glaciation remains undated; however, the chronology of outwash terrace gravel dated to 12.7 ± 1.3 ka indicates that the RBS-1 probably represents the Last Glacial Maximum (LGM). The second glacial advance (RBS-2) is preserved as a curvilinear lateral moraine and is dated to 6.1 ± 0.4 ka. The third glacial advance viz. RBS-3 is bracketed between 5.0 ± 0.5 and 4.0 ± 0.4 ka. Following this, the glacier receded in pulses that are represented by two distinct recessional moraines (RBS-3a and b). The forth glacial stage (RBS-4), which is dated between 2.2 ± 0.2 and 1.6 ± 0.2 ka, shows a pulsating recession and is represented by a prominent recessional moraine (RBS-4a). Whereas, presence of unconsolidated, poorly defined moraine mounds proximal to the glacier snout are ascribed as neoglacial advance corresponding to the Little Ice Age (LIA). With the limited chronometric data, we speculated that the glaciation was driven during the weak to moderate Indian Summer Monsoon (ISM) aided by lowered temperature. Presence of recessional moraines associated with mid-Holocene glacial phase indicate that the monsoon-dominated glaciers respond sensitively to minor (sub-millennial scale) changes in temperature and precipitation conditions. The observations are broadly in accordance with the studies carried out in other monsoon-dominated valleys in the central Himalaya, implying that in ISM dominated regions, lowered temperature seems to be the major driver of glaciations during the late glacial to late Holocene.

1. Introduction

The sensitivity of the Himalayan glaciers to the temporal changes in precipitation and temperature are used successfully to reconstruct the past climate variability (Ali and Juyal, 2013; Ali et al., 2013; Sati et al., 2014; Bisht et al., 2015; Sharma et al., 2016). Particularly, the reconstruction of Holocene glacier fluctuations has grown in significance owing to the anticipated global climate change (IPCC, 2007; WGMS, 2008). The study pertaining to the Holocene glacier fluctuation allows us to verify and eventually adjust the glacier models for predicting future glacier changes (Winkler and Matthews, 2010). In recent times, significant progress has been seen in the Holocene glacier chronologies from the Himalayan-Tibetan orogen (e.g., Ali et al., 2013; Owen and Dortch, 2014; Sati et al., 2014; Bisht et al., 2015). Considering that the Holocene period has experienced centennial to millennial scale climatic oscillations (Hong et al., 2003; Wang et al., 2005; Fleitmann et al., 2007), glacier response particularly from the ISM-dominated regions like the central Himalaya needs to be understood. Some studies from this region (e.g., Ali et al., 2013; Sati et al., 2014; Bisht et al., 2015) have demonstrated that the moraines left behind by receding glaciers can be used to infer relative changes in past precipitation and temperature.

In addition to this, the timing and amplitude of Holocene glaciation has become extremely important because studies suggest that despite an increase in the solar insolation, glaciers in the southern part of the Himalayan ranges advanced during the early Holocene (Rupper et al., 2009). Himalayan glaciers are nurtured by the mid-latitude westerlies and ISM (Finkel et al., 2003; Yang et al., 2008) and the influence of these two weather systems varies spatially and temporally (Benn and Owen, 1998). For example, in the central Himalaya, studies suggest that an increased landward moisture flux during the LGM (Dykoski et al., 2005; Sinha et al., 2005; Wang et al., 2005; Herzschuh, 2006)

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Assessing operative natural and anthropogenic forcing factors from long-term climate time series of Uttarakhand (India) in the backdrop of recurring extreme rainfall events over northwest Himalaya

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ABSTRACT

The entire Indo-Himalayan region from northwest (Kashmir) to northeast (Assam) is facing prevalence of floods and landslides in recent years causing massive loss of property, human and animal lives, infrastructure, and eventually threatening tourist activities substantially. Extremely intense rainfall event of 2013 C.E. (between 15 and 17 June) kicked off mammoth flash floods in the Kedarnath area of Uttarakhand state, resulting in huge socioeconomic losses to the state and country. Uttarakhand is an important hilly region attracting thousands of tourists every year owing to numerous shrines and forested mountainous tourist spots. Though recent studies indicate a plausible weakening of Indian summer monsoon rainfall overall, recurrent anomalous high rainfall events over northwest Himalaya (e.g. ~2010, 2013, and 2016) point out the need for a thorough reassessment of long-term time series data of regional rainfall and ambient temperatures in order to trace signatures of a shifting pattern in regional meteorology, if any. Accordingly, here we investigate ~100-year-long monthly rainfall and air temperature time series data for a selected grid (28.5°N, 31.25°N; 78.75°E, 81.25°E) covering most parts of Uttarakhand state. We also examined temporal variance in interrelationships among regional meteorological data (temperature and precipitation) and key global climate variability indices using advance statistical methods. Major findings are (i) significant increase in pre-monsoon air temperature over Uttarakhand after 1997, (ii) increasing upward trend in June–July rainfall and its relationship with regional May temperatures (iii) monsoonal rainfall (June, July, August, and September; JJAS) showing covariance with interannual variability in Eurasian snow cover (ESC) extent during the month of March, and (iv) enhancing tendency of anomalous high rainfall events during negative phases of Arctic Oscillation. Obtained results indicate that under warming scenario, JJ rainfall (over AS) may further increase with occasional extreme rainfall spells when AO index (March) is negative.

1. Introduction

The Indo-Himalayan region from northwest to northeast (Kashmir to Assam) acts as a barrier for ascending moisture-laden clouds that are advecting northward with the seasonal northward movement of Intertropical Convergence Zone (ITCZ) during boreal summer. This brings summer monsoon precipitation over all mountainous, Himalayan foothills and plain regions of India, Pakistan, Nepal, Bangladesh, and Myanmar. In Northwest Himalayan region Kashmir, Himachal Pradesh, and Uttarakhand (UKS) are three major hilly regions that are characterised by several mountain peaks, valleys, glaciers, rivers, and thick forest cover supporting a large biodiversity. Among the three northwest Himalayan states, UKS has special importance for having several sacred shrines and tourist spots that are visited by a number of pilgrims/tourists every year during summer. The period of famous holy pilgrimage (the Char dham yatra) overlaps with the early summer monsoon period as typically summer monsoon rainfall may arrive over UKS from second to third week of June, gripping the entire state by mid of July. The source of moisture during summer monsoon precipitation is mainly from the Bay of Bengal but in certain cases moisture from the Arabian Sea can also contribute (Sengupta and Sarkar, 2006).

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Paleofloods records in Himalaya

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ABSTRACT

We use paleoflood deposits to reconstruct a record of past floods for the Alaknanda-Mandakini Rivers (Garhwal Himalaya), the Indus River (Ladakh, NW Himalaya) and the Brahmaputra River (NE Himalaya). The deposits are characterized by sand-silt couplets, massive sand beds, and from debris flow sediment. The chronology of paleoflood deposits, established by Optically Stimulated Luminescence (OSL) and ^{14}C AMS dating techniques, indicates the following: (i) The Alaknanda-Mandakini Rivers experienced large floods during the wet and warm Medieval Climate Anomaly (MCA); (ii) the Indus River experienced at least 14 large floods during the Holocene climatic optimum, when flood discharges were likely an order of magnitude higher than those of modern floods; and (iii) the Brahmaputra River experienced a megaflood between 8 and 6 ka. Magnetic susceptibility of flood sediments indicates that 10 out of 14 floods on the Indus River originated in the catchments draining the Ladakh Batholith, indicating the potential role of glacial lake outbursts (GLOFs) and/or landslide lake outbursts (LLOFs) in compounding flood magnitudes. Pollen recovered from debris flow deposits located in the headwaters of the Mandakini River showed the presence of warmth-loving trees and marshy taxa, thereby corroborating the finding that floods occurred during relatively warm periods. Collectively, our new data indicate that floods in the Himalaya largely occur during warm and wet climatic phases. Further, the evidence supports the notion that the Indian Summer Monsoon front may have penetrated into the Ladakh area during the Holocene climatic optimum.

1. Introduction

Under the influence of the Indian Summer Monsoon (ISM), rivers originating in the Himalaya and Tibet are susceptible to flooding. Therefore, >15% of the world's population, which is supported by the major Himalayan rivers, including the Indus, Ganga, Brahmaputra and Yangtze, are at risk from flooding (Webster et al., 2011). As an example, in the Garhwal Himalaya extreme rainfall in 2013 led to the most catastrophic flood of the millennium (Sundriyal et al., 2015; Ziegler et al., 2014). In general, large floods in the Upper Ganga Catchment are frequent. For example, there have been two significant 'flash' floods in the recent history of the Alaknanda River (1894 and 1970; Wasson et al., 2008; Rana et al., 2013) prior to the 2013 event. Further, paleoflood deposits show that there have been 12 major floods on the Alaknanda in the last 800 years – equivalent to more than one every century (Wasson et al., 2008, 2013). The frequency of flooding in the upper Ganga, as well as other large Himalayan rivers, demonstrates the need for long-term records of high-magnitude floods to assess flood risk in the Himalayan region – an area where even short-term discharge and rainfall records are rare (Negi, 2002).

Paleoflood hydrology enables the extension of flood histories beyond the instrumental records and thus can provide long-term records of flood frequency, magnitude and trends (Kochel and Baker, 1982). Floods in the Himalaya often occur in response to heavy rainfall during the annual monsoon period or as a result of a monsoon anomaly (Kale, 2004; Ziegler et al., 2014). According to Rasmussen and Houze (2012), flash floods result from a myriad of storm types with differing structures and synoptic conditions (cf. Doswell, 1985; Doswell et al., 1996; Maddox et al., 1978). For example, the 2010 flash flood event in Ladakh (upper Indus) was caused by a large (meso-scale) rain-producing cloud system that formed over the high Himalaya and Tibetan Plateau, and received additional moisture from monsoon air masses moving northward from the Arabian Sea and Bay of Bengal (Rasmussen and Houze,

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Identification of landslide-prone zones in the geomorphically and climatically sensitive Mandakini valley, (central Himalaya), for disaster governance using the Weights of Evidence method

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ABSTRACT

The entire Himalayan region is prone to disasters, with many people being vulnerable to hydroclimatic threats such as extreme rainfall-driven floods, glacial lake outburst floods (GLOFs), landslide lake outburst floods (LLOFs), and landslides triggered by rainfall. Landslides and floods are related, as the former cause the lakes that burst, and floods can undercut slopes and cause landslides. During the past 200 years, landslides and floods caused by LLOFs in the Garhwal Himalaya have occurred in 1894, 1970, and 1978; but the most disastrous event, in terms of loss of life and economic impact, occurred in June 2013, which was a result of extreme rainfall in the Higher Himalaya and breaching of a moraine-dammed lake, very short-lived LLOFs, and rainfall-induced runoff and landslides. Outmigration from the area as a result of the 2013 event has caused anxiety about the future of the economy and also concerns about security of a state that has an international border. As a contribution to planning and reconstruction to secure the livelihoods of the local people and to entice migrants to return, this paper identifies zones in the Mandakini valley susceptible to landslides using a 'Weights of Evidence' approach. The roles of climate, geology, and geomorphology of the valley are also given attention to explain the reasons for the disastrous event of June 2013. The results of the research presented here may be an important input to disaster governance.

1. Introduction

In June 2013 the Uttarakhand Himalaya witnessed an extreme rainfall event that created flooding and large numbers of landslides in many river valleys. Generally, the monsoon occurs in the second week of July in Uttarakhand, but in 2013 it arrived one month early. Owing to high rainfall from 15 to 18 June 2013, rivers had high discharges causing flooding and destruction of lives, livelihoods, and infrastructure. The peak time for Hindu pilgrims to visit the area, particularly Kedarnath temple and also for other tourists, is from May to October. Thus the monsoon period is the time of maximum traffic and high population density in the area with a high risk of exposure of people to hazards because of landslides and floods. The Mandakini valley (in District Rudraprayag) was the worst affected valley in which about 7000 people and hundreds of animals were killed; about 15 km of National Highway 109 were washed away at different locations and at many places roads were blocked by landslides, many of which were caused by undercutting of hillslopes by the flood; 97 residential and 53 commercial buildings were damaged beyond repair; and 136 residential and 29 commercial buildings were partially damaged (Sundriyal, 2015). About 317 families were moved to safer places from 28 villages in District Rudraprayag (source: http://rudraprayag.nic.in). After this disaster many families migrated from the hills to the plains. This outmigration has added to that already underway as a result of poor facilities and degraded agricultural land, leaving about 3600 villages all but deserted (http://timesofindia.indiatimes.com/india/In-Uttarakhand-missing-opportunities-turn-3600-villages-into-ghost-settlements/articleshow/49109857.cms). This trend has caused anxiety in governments with dire consequences for the economy of the State of Uttarakhand and also concern about its strategic position as it has an international border. If people are to be reassured about living in the mountains, and even return to the mountains, governance regimes need to include information about safe and unsafe areas.

So far, most of the studies published on the June 2013 disaster in Uttarakhand have analysed the climate conditions and the man-made factors that aggravated the disaster. These studies are useful for

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Geomorphic evolution of a non-glaciated river catchment in Lesser Himalaya: Response to tectonics

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ABSTRACT

The study discusses detail valley formation and sedimentation processes in the monsoon dominated non-glaciated catchment of the Ramganga river in the Lesser Himalaya. The geomorphic and sedimentological studies in this basin indicates phases of massive aggradation that was controlled mainly by channel bound processes and debris flows/landslides. The luminescence chronology of the fill sequences suggests that the valley filling occurred mainly in response to the enhanced monsoon after the Last Glacial Maxima (LGM), during Medieval Warm Period (MWP) and Little Ice Age (LIA). This phase is common in both glaciated and the non-glaciated catchments of Himalaya.

The Ramganga River that flows through various tectonic structures of the Lesser Himalaya shows development of wide valleys with thick fill deposits in the fault zones. Chaukhutiya Fault (CF) and Binau-Bhikiyasain-Naurar Fault (BBNF) are the two main transverse faults where the evolved geomorphology pertains to their tectonic activity. The computed morphometric variables such as Ratio of valley floor width to valley height (Vf) and Stream Gradient Index (SL) show higher values in the transverse fault zones. Basin asymmetry vectors along the South Almora Thrust and BBNF are characterized by preferred stream migration in NE and SW direction suggesting BBNF with dip slip movement. Thick clay deposits at different sites along the Ramganga River resulting from blocking of the river, particularly along the BBNF, also point towards tectonically induced landslide and channel blockage. Later phase of tectonic activity, bracketed between 27 and 24 ka, is evident from deformed fluvial deposits in the form of folds and faults. Evidences of tectonic activity in the form of soft sediment deformation structures (SSDS) generic to seismic activity in layers comprising alternation of clay and sand are observed in the Himalayan Frontal Thrust (HFT) zone. The diagnostic features such as dykes, faults and folds suggests that the shaking event took place between 38 ka and 30 ka.

1. Introduction

The rivers that originate in Lesser Himalaya are non - glaciated catchments and are generally fed by groundwater and southwest monsoon. Major river systems that originate in higher and Tethys Himalaya are generally fed by glaciers in their source areas. Rivers like the Ganga, the Sutlej, the Yamuna and the Brahmaputra, etc originating from the elevation of >4000 m amsl and fed by several hundreds of large and medium sized glaciers located in the Higher Himalaya are extensively studied (Srivastava and Misra, 2008; Srivastava et al., 2009; Sinha et a., 2010; Dutta et al., 2012) for the genesis and climatic significance of fluvial terraces, debris flows, alluvial fans, landslides, epigenetic gorges, and paleo-flood. Fluvial and glacio-fluvial landforms in these river systems have been widely investigated to understand relationship between palaeo-glaciation, monsoon variability and fluvial dynamics (Church and Slaymaker, 1989; Ray and Srivastava, 2010; Juyal et al., 2010; Srivastava et al., 2013,Pratt-Sitaula et al., 2004). Further, the Himalaya is cut across by an extensively active fault system (Nakata et al., 1984; Nakata and Kumahara, 2002) along with southward

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Section – Geohazards and Environment
Technical Note

Landslide Hazard Zonation Study in Eastern Indian Himalayan Region

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Abstract: Sikkim State in the eastern Indian Himalayan Region experiences intensive landslides because of its geologically brittle terrain coupled with heavy rainfall and anthropogenic influences. Based on satellite images and a toposheet from the Survey of India, a total of 50 landslides were identified in a study area of 133.8 km^2. Among them, 43 were validated in field survey. The important factors for landslide hazard are identified and thematic maps are prepared in ArcGIS. Impacting factors including geomorphologic properties, drainage and soil conditions are assigned weight factors according to our work knowledge in this region to generate thematic layers in ArcGIS for landslide hazard analysis. A landslide hazard zonation map containing five classes, ranging from very low hazard to very high hazard, is produced. The results provide a reliable database for disaster detection and post disaster management, which is essential to planning developmental activities in this district.

Keywords: landslide inventory, morphometry, landslide hazard zonation, satellite data, thematic layers

1 Introduction

Hill slopes in the Himalayan region are often prone to instability due to unfavourable geological conditions, river systems with active hydraulic erosion, groundwater conditions, deforestation and other anthropogenic influences (Rawat et al 2015a). In addition, external triggering factors such as high annual precipitation and seismic activities also increase the probability of instability of hill slopes. With landslide hazards, the Himalayan region is facing major problems of environmental degradation. Therefore, all civil constructions and associated excavations should be properly planned with adequate geological and geotechnical inputs. For this purpose, there is a great need of landslide susceptibility mapping to identify potential landslide areas. Sikkim State in the eastern Indian Himalayan Region (IHR) covers an area of 7,096 km^2 and bound in the south by the Great Rangit River, Chumbi valley in the east, Nepal in the west and Tibet (China) in the north (Raina and Srivastava 1992). Sikkim Himalayan region is characterized by high denudation rates, its suspended load reaches up to 500-1000 ton/km^2/year (Starkel and Basu 2000). Most of its rivers constantly shift channels due to suddenly high discharges during monsoon seasons (Jana 2002). The study area is in the southern part of Sikkim state.

Landslide is a common disaster in the East district of Sikkim under influences of a variety of causative factors, including geological structures, geo-tectonic activities, changes of river regimes, high slope variation, deforestation, inappropriate land use as well as huge amount of rainfall that acts as a triggering factor. Damages caused by those frequent, sudden and unexpected landslides are enormous and becoming increasingly costly to tackle the associated problems. Various corrective and protective measures have been adopted from time to time but the frequency and magnitude of landslide occurrences have superseded the controlling measures. A partial reason is due to lack of proper understanding of individual landslide characters, mechanisms of slide initiation, as well as in-depth information of the concerned area. It is true that this type of natural disasters cannot be checked thoroughly, but proper remedial measures can reduce the magnitude of occurrences. Thus, it is the high time to prepare such a data base and detailed landslide hazard zonation map to take necessary measures to control those hazards in the study area.

2 Materials and Methodology

2.1 Study Methods

This study includes three components: map interpretation, field surveys and factor analysis. Detail steps are shown in (Figure 1).

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Kinematic analysis of slopes between Preng and Ganderbal, Jammu and Kashmir Himalaya, India

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Abstract: Slope stability is a matter of concern for many projects such as buildings, bridges, hydro projects, highways, railway, canal and tunnels in hilly terrain. The present study is carried out between Preng and Ganderbal in Ganderbal district of Jammu and Kahmir. The Ganderbal hydro project is located on the left bank of the river Sind. The Sind River is one of the tributaries of Jhelum River. Slope Mass Rating (SMR) has been done to identify different classes of slopes, their vulnerability to instability and Kinematic analysis by Markland's Method, as the said method is applied to decipher the possible mode of failure and directions in the study area. The said approach was preferred considering the heterogeneous rock mass and being anisotropic with infinitely variable strength parameters that are difficult to determine precisely.The study concludes with the assessment of rock mass conditions and further categorization into fair and poor categories. As the area is facing the recurrences of mass wasting and slope failures, it could broadly be classified into planar and wedge failure. An attempt has been made for the assessment of the rock mass leading to better alignment of highways, tunnels and to foresee any potential rock slope failure during excavation/construction.SMR study concludes that the area falls in partially stable to unstable class.

Key words: Kinematic Analysis, Markland's Test, SMR, Ganderbal, Jammu and Kashmir Himalaya.

सारांशः पहाड़ी क्षेत्रों में पहाड़ियों के ढाल की स्थिरता कई परियोजनाओं जैसे भवन, पुल, जलविद्युत परियोजना, राजमार्ग, रेल–लाइन, नहरों तथा सुरंगों के निर्माण में चिंता का विषय होता है। प्रस्तुत शोध पत्र में ढालों की स्थिरता का अध्ययन प्रेंग तथा गंदेरबल के मध्य किया गया है, जो कि जम्मू एवं कश्मीर राज्य के गंदेरबल जिले के अंतर्गत आता है। गंदेरबल जल–विद्युत परियोजना सिंद नदी के बांये तट पर स्थित है। सिंद नदी झेलम नदी की सहायक नदियों में से एक है। ढ़ालों की स्थिरता का मूल्यांकन ढालों के विभिन्न वर्गों की पहचान के लिए, ढालों की संवेदनशीलता एवं अस्थिरता का आकलन मार्कलैण्ड विधि द्वारा प्रगतिकी विश्लेषण के माध्यम से किया गया है। क्योंकि यह विधि ढालों के सरकने या क्षरण होने की दिशा तथा संभावित प्रकार का आकलन करने के लिए उपयुक्त है। उक्त विधि को इसलिए भी वरीयता दी गयी है क्योंकि अध्ययन क्षेत्र में विजातीय शैलो की अधिकता है जिसके कारण असमदैशिक एवं असंख्य परिवर्तनशील कारकों तथा मजबूती की स्थिति को विशुद्ध रूप से ज्ञात करना कठिन है। इस अध्ययन से यह निष्कर्ष निकाला गया है कि शैलों की स्थिति का आकलन उन्हें पुनः विभाजित करके सुदृढ़ एवं कमजोर क्षेत्र को बार–बार वृहत क्षरण एवं ढालों के गिरने / सरकने का सामना करना पड़ता है। ऐसी स्थिति में मोटे तौर पर शैलों के टूटने को फानाकार एवं तलीय टूटन में विभाजित किया गया है। प्रस्तुत अध्ययन में शैलों के लक्षणों के आंकलन के आधार पर प्रमुख रूप से राजमार्गों तथा सुरंगों के निर्माण के लिए उपयुक्त रेखन का प्रयास किया गया है, तथा खुदाई एवं निमार्ण कार्य के समय अनुमानित एवं संभावित शैल टूटन का आकलन किया गया है। उक्त विधि से ढालों की स्थिरता के मूल्यांकन के पश्चात् यह निष्कर्ष निकलता है कि उक्त क्षेत्र आंशिक रूप से स्थिर व आंशिक रूप से अस्थिर श्रेणी में आता है।

सूचक शब्दः प्रगतिकी विश्लेषण, मार्कलैण्ड विधि, ढालों की स्थिरता का मूल्यांकन, गंदेरबल, जम्मू एवं कश्मीर हिमालय।

INTRODUCTION

The Himalaya being the youngest mountain chain of the world is tectonically and climatically sensitive (Poonam *et al.* 2017, Sundriyal *et al.* 2015). Problems of slope failure are very common in the Himalayan region. Every year the region faces several landslides, which create risk to human lives and infrastructures such as highways and civil structures like dams, buildings etc. Landslide is defined as the movement of a mass of rock, debris or earth down a slope (Cruden 1991), can be triggered by a variety of external stimuli, such as heavy rainfall, intense earthquake, water level change, and rapid stream erosion that cause a rapid increase in shear stress or decrease in shear strength of slope- forming materials (Asthana & Sah 2007; Bhambri *et al.* 2017; Chaudhary *et al.* 2010).

The state of Jammu & Kashmir is strategically very sensitive and distinct with respect to topography and climate, most part of the state is mountainous; the topography along with the climatic condition and various anthropogenic interventions have made it susceptible to natural hazards. Landslides are one of the natural hazards that are common and peculiar to the state. Almost every year the state faces the problem of landslides which affect society in many ways like loss of lives, damage to houses, agricultural land and other infrastructures like roads and dam sites. The vulnerability has increased because of presence of unstable and fragile lithology, seismicity and various unscientific developmental activities. Deforestation, unscientific construction, terracing, encroachment on steep hill slopes are a few and foremost anthropogenic activities which have increased the frequency and intensity of landslides.

The study area comes around a proposed New Ganderbal Hydro Electric Project in Ganderbal district (Fig. 1A). It is a run-off the river scheme located on the left bank of Sind river. Besides power generation, the project envisages providing drinking water facilities and irrigation to the local command

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Full length article

Estimation and applicability of attenuation characteristics for source parameters and scaling relations in the Garhwal Kumaun Himalaya region, India

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ABSTRACT

Source parameters of the small to moderate earthquakes are significant for understanding the dynamic rupture process, the scaling relations of the earthquakes and for assessment of seismic hazard potential of a region. In this study, the source parameters were determined for 58 small to moderate size earthquakes ($3.0 \leq M_w \leq 5.0$) occurred during 2007–2015 in the Garhwal-Kumaun region. The estimated shear wave quality factor ($Q_\beta(f)$) values for each station at different frequencies have been applied to eliminate any bias in the determination of source parameters. The $Q_\beta(f)$ values have been estimated by using coda wave normalization method in the frequency range 1.5–16 Hz. A frequency-dependent S wave quality factor relation is obtained as $Q_\beta(f) = (152.9 \pm 7)\, f^{(0.82 \pm 0.005)}$ by fitting a power-law frequency dependence model for the estimated values over the whole study region. The spectral (low-frequency spectral level and corner frequency) and source (static stress drop, seismic moment, apparent stress and radiated energy) parameters are obtained assuming ω^{-2} source model. The displacement spectra are corrected for estimated frequency-dependent attenuation, site effect using spectral decay parameter "Kappa". The frequency resolution limit was resolved by quantifying the bias in corner frequencies, stress drop and radiated energy estimates due to finite-bandwidth effect. The data of the region shows shallow focused earthquakes with low stress drop. The estimation of Zúñiga parameter (ε) suggests the partial stress drop mechanism in the region. The observed low stress drop and apparent stress can be explained by partial stress drop and low effective stress model. Presence of subsurface fluid at seismogenic depth certainly manipulates the dynamics of the region. However, the limited event selection may strongly bias the scaling relation even after taking as much as possible precaution in considering effects of finite bandwidth, attenuation and site corrections. Although, the scaling can be improved further with the integration of large dataset of microearthquakes and use of a stable and robust approach.

1. Introduction

Determination of seismic moment, stress drop, source dimension and radiated seismic energy of shallow focused small to moderate sized earthquakes ($M_w \leq 5.0$) is an important seismological problem for assessment of seismic hazard potential of a region. Variation in stress drop with space-time is a vital aspect to estimate energy and seismic hazard analysis.

Following Brune's model, several researchers (e.g. Fletcher, 1980; Archuleta et al., 1982; Sharma and Wason, 1994; Kumar et al., 2012) have contributed in the estimation of source parameters of the physical processes that releases the energy at the source. Numerous studies have been conducted to estimate source parameters to develop the scaling law relations between spectral and source parameters of the local seismic events in the Garhwal and Kumaun region (e.g. Sharma and Wason, 1994; Paul, 2010; Kumar et al., 2012; Borkar et al., 2013; Sivaram et al., 2013; Paul and Singh, 2017). In this part of the NW Himalaya, the huge amount of stress concentrates in the upper crust and it is released partially in the form of micro-earthquakes (Paul, 2010).

For 1991 Uttarkashi earthquake, the evaluated stress drop values by Sriram and Khattri (1997) and Kumar et al. (2014a,b) were 60 bars and 52.6 ± 5.9 bars, respectively. Using SH wave spectral analysis, Kumar (2011) estimated the stress drop value of 53.2 ± 6.9 bar for 1999

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Invited research article

Late Pleistocene history of aggradation and incision, provenance and channel connectivity of the Zanskar River, NW Himalaya

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ABSTRACT

The Zanskar River, one of the largest tributaries of the upper Indus catchment, drains transversely northward from the Higher Himalaya, dominated by the Indian summer monsoon, to flow through the arid, westerlies-dominated, highly folded and thrusted Zanskar ranges in Ladakh. The Doda and the Tsarap Lingti Chu join to form the Zanskar, which in turn joins the Indus at Nimu. With an average gradient of ~ 4 m/km, the Zanskar has a gradient ~2.5 times lower than that of rivers like the Ganga and Brahmaputra, which flow through the southern wet Himalaya. Based on Stream Length (SL) gradient index and valley width and height ratio, the Zanskar valley can be divided into upper and lower divisions, separated by a gorge of nearly 60 km length. The river channel in both the divisions is flanked by 10–30 m thick valley-fill deposits that in the upper part are amalgamated with fan and paleolake deposits. Using these fills and incorporating morpho-stratigraphy, Optically Stimulated Luminescence (OSL) dating and provenance analysis based on U—Pb Zircon chronology, the study show that the Zanskar valley aggraded in three phases: (i) the oldest phase during ~43 to ~32 ka (cool and wet MIS 3), (ii) during 20–12 ka, a climatic transition from the dry LGM to the wet early Holocene and (iii) the youngest aggradation phase commenced between 9 and 6 ka, corresponding with the strengthened monsoon phase of the early–mid Holocene. The study implies that, during the oldest aggradation phase, the wider Padam basin stored 3.25 ± 0.11 km^3 of sediment, which, in the present geomorphic setup is 0.96 ± 0.10 km^3. The provenance analysis suggests that, despite the presence of the deep narrow gorge and a low gradient, the upper and lower Zanskar valleys remained connected throughout their aggradational history. Unlike in the southern wetter Himalaya, where catchment-wide exhumation is the main source of sedimentation, valley filling in the Zanskar basin has been overwhelmed by sediment derived from headward erosion.

1. Introduction

Fluvial systems actively respond to spatio-temporal changes in the climate and to solid Earth forces, and these responses are recorded in the fluvial landscape and sediments. Interplay between tectonic and climatic forces drives landscape development during active orogeny; however, the effects and resultant erosion pattern from these drivers remain a matter of curiosity (Starkel, 2003). The hotspots of erosion and deposition in a river valley in an active mountain system are governed by the pattern of rainfall distribution and its interaction with various tectonic discontinuities. In the Himalaya, for example, river terrace and valley-fill chronologies suggest that drier climatic phases have led to valley filling and that rivers have incised and formed terraces during episodes of wetter climate (Srivastava et al., 2008; Ray and Srivastava, 2010). River systems draining from the southern Himalayan front have been studied extensively so as to understand the connection between the intensified Indian Summer Monsoon (ISM) and the aggradation and incision represented by fluvial terraces (Bookhagen et al., 2005; Srivastava et al., 2008; Srivastava and Misra, 2008; Juyal et al., 2010; Ray and Srivastava, 2010), and the relationship between climate and tectonic activity in the evolution of the Himalaya (Hodges et al., 2004; Pratt-Sitaula et al., 2004; Thiede et al., 2004). These studies suggest that rivers draining the southern front of the Himalaya are, in general, characterized by (i) drier and glaciated headwaters and wetter lower reaches, (ii) high relief (> 3500 m) between the headwaters and the exit from the mountains (~200 km), implying steeper-gradient longitudinal river profiles, and (iii) widespread valley fills that are composed of sediments derived from catchment-wide denudation and

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Characteristics of rain-induced landslides in the Indian Himalaya: A case study of the Mandakini Catchment during the 2013 flood

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ABSTRACT

Landslides triggered by monsoon rainfall are a recurring hazard that lead to loss of life and cause enormous property and infrastructure damage in the Indian Himalaya. This study is focused on understanding the role of extreme rainfall and physical factors in causing landslides in the Indian Himalaya, particularly in the Mandakini Catchment where an enormous landslide and flood disaster occurred in June 2013 following a two-day extreme rainfall event. Results indicate that sub-daily extreme rainfall depths causing landslides vary with elevation across the catchment. Antecedent rainfall six days prior to the extreme rainfall event was found to have substantial depths that could have primed the area for landslides. Except for aspect of slopes, the causative factors including land use/land cover, lithology, elevation, slope, river network, distance to roads, and total extreme rainfall as a triggering factor were found to be statistically significant in causing landslides in the catchment. The final product of the study is a new landslide susceptibility map that better delineates the landslide prone regions in the disaster-prone Mandakini Catchment after the June 2013 extreme rainfall event. The Map was prepared using logistic regression that shows medium and high susceptibility zones at upper sections of the catchment as well as along the Mandakini River and its tributaries where major sacred shrines, tourist spots and human establishments are located.

1. Introduction

The Himalaya is the youngest and the highest mountain range in the world, where several religious and tourist destinations are located that are visited by thousands of people every year (Ziegler et al., 2014; Champati Ray et al., 2016). The Indian Himalaya is also geomorphologically unstable due to the intense monsoon precipitation regime and tectonic activity, contributing to the occurrence of a range of environmental hazards, including earthquakes, landslides, landslide lake outburst floods (LLOFs), glacial lake outburst floods (GLOFs) and flash floods (Bilham, 2004; Mugnier et al., 2013; Wasson et al., 2013; Ziegler et al., 2014; Allen et al., 2016). Such natural hazards transform into disasters due to rising populations, poorly regulated tourism industry, and poor infrastructure development including road network expansion in environmentally sensitive zones (Ziegler et al., 2014; Bhambri et al., 2016). The 2013 landslide and flood disaster in the Indian Himalaya, particularly in the Mandakini Catchment and its neighborhood in the Garhwal Himalaya (part of the Indian Himalaya), was a harsh reminder to residents, visitors, and government officials of the vulnerability within the Indian Himalaya, which is both inherent and arguably growing (ADB, 2013; Das, 2013; Ziegler et al., 2014) (Fig. 1).

In this paper, the recent landslide and flood event of 2013 is adopted for the study. The 2013 disaster in the Mandakini Catchment is now considered to be the largest rainfall-induced landslide and flood disaster in the last millennium across the Indian Himalaya in the Uttarakhand state of India (Wasson et al., 2013) (Fig. 1). On the 16th and 17th June 2013, high depths of rainfall occurred in the Mandakini Catchment that triggered a large flash flood and several deadly landslides in the region (Martha et al., 2015; Sundriyal et al., 2015; Rawat et al., 2015; Poonam et al., 2016). The Wadia Institute of Himalayan Geology (WIHG) meteorological observatory at Chorabari Glacier camp (3820 m) reported a total rainfall of 325 mm during the rainfall event (Dobhal et al., 2013). Two waves of flood were reported by several authors during the evening of June 16 and morning of June 17 respectively (Dobhal et al., 2013; Ziegler et al., 2014; Champati Ray et al., 2016). The first wave of flood in the evening of June 16 accumulated sediment and debris in the Kedarnath town and in downstream areas that was transported by the Mandakini River. The second wave of flood occurred in the morning of June 17 after the outburst of the Chorabari Lake that released large amounts of water that further transported debris and large boulders

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WILEY

RESEARCH ARTICLE

Spatial interrelationship of landslides, litho-tectonics, and climate regime, Satluj valley, Northwest Himalaya

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Landslides have been considered widely as principal mass wasting agents in the valleys experiencing varied influence of tectonics and climate. However, pattern of landslides is rarely addressed in the literature that may act as a surface manifestation of interrelationship of tectonics, climate, and lithology. Here, we have attempted to understand such interrelationship in the context of landslide distribution pattern in the Satluj valley, Northwest Himalaya. Geomorphic indices such as steepness index, valley floor width to valley height ratio, and topographic swath profile were used for tectonic inference. Daily rainfall data of the year 2000–2016, using 5 rain-gauge stations and swath profile of Normalized Difference Vegetation Index, were used to deduce spatial variability of climate. Influence of lithological variability and regional faults; Sangla Detachment, Main Central Thrust, and Munsiari Thrust on the landslide distribution are also inferred. A total of 55 landslides (20 rock avalanche, 19 debris slides, and 16 rockfalls) are found to exist in 6 clusters along 130 km stretch of the Satluj valley. These landslides, covering a total area (A) and volume (V) of 1.05×10^7 m^2 and 4.4×10^7 m^3, respectively, are also noted to follow a power law ($R^2 = 0.8$) and result in a scaling relationship of $V = (0.180)A^{1.208}$.

KEYWORDS

climate, landslide, litho-tectonic, Northwest Himalaya, Satluj valley

1 | INTRODUCTION

Landslides are one of the principal mass wasting process in tectonically active mountains (Ballantyne, 2002; Hovius, Stark, & Allen, 1997; Sanchez et al., 2010; Shroder, 1998). Climate has also been considered to control the distribution and frequency of landslides (Borgatti & Soldati, 2010 and reference therein). Spatio-temporal interrelationship of tectonics and climate has often been noticed in the collisional orogeny. Hillslope erosion is a primary component of such interrelationships where surface imprints are generally landslides (Ballantyne, 2002; Hovius et al., 1997; Korup, Densmore, & Schlunegger, 2010). Such erosional regime, however, has been noted to vary spatio-temporally due to varying climate and tectonic conditions (Thiede, Ehlers, Bookhagen, & Strecker, 2009). Besides tectonics and climate, local factors such as lithology and structures have also been noted to control the occurrence and distribution of landslides (Guzzetti, Cardinali, & Reichenbach, 1996; Sanchez et al., 2010).

Nonetheless, interrelationship of these factors; climate, tectonics, lithology, and structures have rarely been associated with spatio-temporally varying landslide distribution pattern. Such distribution pattern has been found useful for hazard assessment, landscape evolution, and recently to evaluate the influence of climate change (Borgatti & Soldati, 2010; Crozier, 2010; Hovius et al., 1997; Reichenbach, Galli, Cardinali, Guzzetti, & Ardizzone, 2004). However, there are many limitations to infer temporally varying landslide distribution, such as delineation of individual failure events on reactivated landslide, loss of landslide scarp caused by successive mass movement, vegetation growth on detached debris, and dating constraints (Lang, Moya, Corominas, Schrott, & Dikau, 1999). But spatial distribution can be achieved easily using high-resolution satellite imagery and subsequent ground truthing, and hence, this study pertains to such spatial distribution pattern.

Recently, Google Earth (GE) Imagery have been used widely for the landslide distribution mapping owing to high resolution, free, easy,

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Geo-environmental consequences of obstructing the Bhagirathi River, Uttarakhand Himalaya, India

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ABSTRACT

The Bhagirathi Valley is investigated to understand the impact of various barrages and dams on natural river flow. The multiple barrages and dams in the valley (downstream of the Bhatwari Village) have obstructed/disrupted natural flow of the river which has adversely impacted geomorphological and ecological functions of the river. Besides, it is observed that during and after the implementation of the hydropower projects, the terrain stability was severely affected due to creation of fresh landslide zones, destruction of forest and rural infrastructures including the marginal agricultural lands. The study observes that lack of detailed geological, geomorphological and ecological investigation prior to the execution of the hydropower projects led to the terrain instability. Further, dearth of detailed scientific studies was responsible for the lack of comprehensive engineering/bioengineering measures and catchment area treatment plans as also the measures for reservoir rim slope stability. Taking cognizance from the Bhagirathi valley, present study calls for a detailed multidisciplinary study in the Himalayan valleys where the rivers are likely to get impounded for harnessing hydropower.

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KEYWORDS
Dams and reservoirs; collateral damage; slope instability; reservoir drawdown

1. Introduction

The Himalaya, one of the youngest orogenic belts and ecologically sensitive terrain is severely impacted by soil erosion, landslides, and flash floods. The recent most example is the June 2013 Uttarakhand Disaster which not only took a heavy toll on life but also severely damaged various hydropower projects in the region (Theopheophilus, 2013; Sati and Gahalaut 2013; Ravi Chopra Committee report 2014; Sundriyal et al. 2015). Studies suggest that the majority of the Himalayan floods originate in the vicinity of the southern flank of the Higher Himalayan Crystalline (HHC) also known as the southern mountain front. These floods are largely associated with the Landslide Lake Outburst Floods (LLOFs) (Kimothi and Juyal 1996;

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A PRELIMINARY ASSESSMENT OF THE GEOLOGICAL EVIDENCE OF THE MEGA FLOODS IN THE UPPER ZANSKAR CATCHEMENT, NW HIMALAYA

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ABSTRACT

Mega floods generated due to catastrophic lake outburst in the Tsrap Lingti Chu (upper Zanskar valley) indicate that the Glacial Lake Outburst was the major factor which is popularly known as Glacial Lake Outburst Floods (GLOFs). Optical chronology suggests that the floods occurred during the later part of the Marine Isotopic Stage-3 dated to ~39 ka and during post Last Glacial Maximum (LGM) dated to ~15 ka. Flow velocity using the sedimentological criteria and employing empirical methods provides a broad estimate of 9.98±1.5 m/s for the flood deposits dated to 15 ka. The minimum paleo discharge of 39 ka flood event is estimated to be 9702.67±537.3 m^3/s. The study suggests that the floods occurred during the wet and warm climate conditions.

Keywords: Paleo flood, Paleo discharge, GLOFs, Optical chronology, north western Himalaya.

INTRODUCTION

Catastrophic mega-floods which are associated with spontaneous release of large amount of impounded water, like landslide lake outbrust floods (LLOFs), Glacial lake outbrust floods (GLOFs) and floods due to extreme weather conditions, intensively affect the morphology of the orogeny (Baker *et al*., 1993; Richardson and Reynolds, 2000; Korup and Clague, 2009; Dortch *et al*., 2011; Sundriyal *et al*., 2015; Poonam *et al*., 2017). Seasonal flooding, which are associated with increase in temperature and precipitation and have a nearly fixed frequency of every year, are mainly responsible for transportation–deposition of sediment within the channel limits, as their velocity and discharge are in the lower flow regime. Whereas, mega flood events are accompanied by large-scale mass movement causing lateral and vertical incision; however transient storage of sediments from these floods provides an evidence of their occurrence and intensity. As compared to Ganga plains and Tibetan Plateau, Himalayan orogen is known to witness for the higher extreme events. These events are more frequent in the dry Trans Himalayan region (Bookhagen, 2010). For example, to name a few, on August 6th, 2010 a cloud burst triggered debris flow generated flash flood, having peak discharge of >1000 m^3/s, that virtually devastated the Leh Valley (Hobley *et al*., 2012; Thayyen *et al*., 2013). On 7th May 2015, due to damming of Tsarap Lingti Chu near Phugtal, which stored nearly 35×10^6 m^3 water, a LLOF was generated in the Zanskar causing unprecedented damage in the valley. Considering that the arid Trans Himalayan region of NW India is witnessing rapid urbanization (> 20% over a time period of two decades, from 1981 to 2001) (Goodall, 2004), it is considered as one of the most vulnerable terrain in terms of its susceptibility towards unusual weather events (Ziegler *et al*., 2016). It has been suggested that under the warm earth scenario, there would be an increase both in frequencies and magnitude of floods in the Himalayan region (Agnihotri *et al*., 2017, Wasson *et al*., 2013). In view of this, it is important to understand the causes of the floods both during the historical (geological archives) and in the recent past in order to generate the data so that it can feed to the model of simulation for future prediction. Towards this, beyond the instrumental records, sedimentary archives of paleo floods becomes important that are used extensively in the recent times (Kochel and Baker, 1982; Kale, 2000; Wasson *et al*., 2013; Sharma *et al*., 2017; Srivastava *et al*., 2017). Sedimentary records of large flood over a time scales of 10^3-10^4 year are wide spread in the Himalayan ranges (Burbank, 1983; Cornwell, 1998; Richardson and Reynolds, 2000; Seong *et al*., 2009; Wasson *et al*., 2013; Sharma *et al*., 2017; Srivastava *et al*., 2017; Panda *et al*., 2020). These archives can be preserved as Slack water deposits (SWDs) (Wasson *et al*., 2013; Sharma *et al*., 2017; Srivastava *et al*., 2017), massive sand beds on fluvial terraces (Montgomery *et al*., 2004; Lang *et al*., 2013; Panda *et al*., 2020), and debris flow deposits (Bookhagen *et al*., 2005). Paleo- hydrological assessment of these archives provides the information about the intensity of these events. In the present study an attempt has been made to generate paleo-flood data, using sedimentary archives of past floods that are preserved along the Tsarap Lingti Chu, which is one of the tributary of the Zanskar River (Fig. 1). The objective of the study is to understand the causes of the paleo-floods and their geomorphic implications on the terrain. To achieve the above objective we used the conventional sedimentological criteria supported by the Optical Stimulated Luminescence (OSL) dating.

REGIONAL SETTING

Tsarap Lingti Chu is a major tributary of upper Zanskar catchment flowing in a deep narrow gorge and has ~8570 km^2 of catchment area. It follows the strike of Zanskar shear Zone, which is north dipping extensional structure and is a part of 2000 km long South Tibetan Detachment system (STDs) (Herren, 1987; Dèzes *et al*., 1999). Tsarap Lingti Chu has Indian Summer Monsoon (ISM) dominated Higher Himalayan Crystalline (HHC) sequence toward south and relatively dry Zanskar ranges at the north. The paleo-flood deposit in the form of massive sand bodies are preserved on the southern bank of Tsarap Lingti

Quest for disaster-resilient roads in the Himalaya

Shubhra Sharma, S. P. Sati, Y. P. Sundriyal, Vikram Sharma and Harsh Dobhal

Mountain roads are important lifelines and the most critical means for connectivity in the Himalayan villages of India. However, the inherent geological, geomorphological, ecological and climate fragility of the terrain warrants critical scientific investigations for the roads to sustain the vagaries of nature. Further, the increased frequency of extreme events with the ongoing climate change increases the potential impact of disasters. This note highlights the major challenges and issues faced with the ongoing road-widening projects in the country. It cautions against the uniform standard of road widening and the need to increase sensitivity towards appreciating the terrain fragility.

In recent times, slope instability associated with the Himalayan roads in India has increased, resulting in serious damage to life and property. For example, Himanchal Pradesh, India, experienced multiple slope failures such as the tragic Kinnaur (Chaura village), Nahan–Kumarhatti and Pandoh (near Mandi town) in 2021. Similar incidences were observed in the adjoining Uttarakhand Himalaya. Such tragic incidences, certainly raised concern about the stability of the Himalayan roads and thus, the safety of the local inhabitants. It is pertinent to understand whether these road-proximal disasters are the geomorphic expression of slopes to extreme weather events or the result of unscientific tampering without adequate understanding of the Himalayan geology and structures.

Infrastructure expansion is occurring at a dramatic rate across the globe and the Himalaya is no exception. Paved roads have increased by ~12 million km worldwide since 2000, with an additional ~25 million km projected by mid-century[1,2]. Majority of the roads are being built in developing nations, including many ecologically sensitive regions such as the Himalaya which is exceptional in terms of wilderness, biodiversity, ecosystem services, and rare and endangered species[3]. The success of Himalayan road projects lies in early assessment of the risk posed by potential geohazards, particularly the slope instability caused due to excavation of steep slopes. This can be achieved with focused scientific studies of the terrain before route alignment, identification of hazard-prone locations, as well as proactive and persistent planning of slope management following road construction.

During May 2017 in Hanoi, Vietnam, around 160 leading financiers, decision-makers, ecologists and social-development specialists deliberated upon the strategies to limit the environmental impacts of roads. It was observed that too much funding is being earmarked for the initial construction of ambitious new road networks and too little for their ongoing maintenance[4]. Further, there is no denial that a few roads are adequately engineered for the challenging local conditions, but there are large number of roads which suffer from ill-planned construction. According to a World Bank study, typically 15–30% (and in some cases ~60%) of road funding in developing nations is lost to cartels and corruption[1].

Besides road stability, an equally important factor is the rapid penetration of roads into many of the world's ecologically sensitive and biodiversity hot spots (national parks and wildlife sanctuaries). From 1993 to 2009, the extent of global wilderness which houses rare and endangered species has declined by about 10% (ref. 3). One of the reasons for this is climate change. The Himalaya is witnessing significant temperature changes since the 20th century. The warming trend during the first half of the 20th century was about 0.16°C per decade, which later doubled to 0.32°C per decade from the beginning of the 21st century[5]. Incidences of forest fire in the Himalaya have increased significantly, which besides weakening the soil cohesiveness (due to heat-induced dryness) is linked to increasing incidences of cloud bursts (soot acting as cloud condensation nuclides)[6] and further cascading into landslides and flash floods.

In Uttarakhand, the Government of India has launched an ambitious Rs 12,000 crores road-widening project called the Char Dham Pariyojna (CDP). Under this project roads (~900 km) are being widened (two-laned widening with paved shoulders), with no environmental clearance required (administratively), since these roads were fragmented into 53 segments having stretches <100 km for which Environment Impact Assessment (EIA) is not mandatory. Nevertheless, the 100 km rule is ineffective, considering the fact that the Himalayan roads traverse through abrupt rise in the altitude gradient, thus trespassing the diverse geological and ecological niches within short distances (Figure 1). With the focus of the current road-widening project on increasing the road width, the critical aspect of disaster resilience and environment has been ignored, rendering it highly prone to slope instability. Studies demonstrate that there is a positive correlation between road width and slope instability causing associated environmental damage in the hilly terrain[7,8]. With the chronic landslides remaining untreatable, in spite of the advancement in engineering measures. Hypothetically, even if an assumption is made about future stability of the slopes, the increased and unregulated tourist (vehicular) inflow would become detrimental to the health of the already stressed Himalayan ecosystem. Hence, there is an ongoing tussle between the development planners and environmentalists, which is rather ironic. Without addressing the ecological and environmental stability of the geologically/geomorphologically fragile slopes riddled with chronic landslides, it would be difficult to achieve the desired objective of providing sustainable disaster-resilient roads.

The Uttarakhand Himalaya lies in the earthquake zones IV and V, and experiences innumerable earthquakes of varying magnitudes. As a result, the rocks are highly fractured, fissile and at places pulverized. Various scientific studies and Government-sponsored, landslide-related projects have already warned about the vulnerability of slopes in Uttarakhand Himalaya[9]. However, little is achieved in terms of stabilization and prevention of landslides[10]. The slope stability becomes particularly critical in the Higher Himalaya

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Article

Geomorphological and Statistical Assessment of Tilt-Block Tectonics in the Garhwal Synform: Implications for the Active Tectonics, Garhwal Lesser Himalaya, India

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Abstract: Active tectonics is manifested in geomorphological features such as drainage basins and drainage patterns. Geomorphic parameters asymmetry factor *(AF)* and transverse topography symmetry factor *(T)* is calculated for 94 third order basins of the Garhwal synform to decipher the tilt-block tectonics based on remote sensing and geographical information system (GIS) techniques. The quantitative analysis of the *AF* suggests that all the 94 basins are asymmetric and gentle to steeply tilted, indicating active tectonics and early and late stage of development, respectively. The mean vector magnitude (θ_v) of *T* suggests the migration of the basin stream towards the south in most basins (60%), suggesting a unidirectional tilting of the tectonic block. The χ^2 test for statistical significance indicates that the θ_v is significant for southern and northern limb basins. The χ^2 test affirms that the third order basin position on either side of the main channel of the river basin influences the tilt direction. The regional tectonics suggests migration of the Lansdowne klippe towards the south, as the majority of third order basins show southward tilt. The study provides a quick appraisal of tilting in the tectonic blocks of active margins, such as in the Himalayas.

Keywords: Himalaya; Garhwal synform; geomorphic parameters; tilt-block tectonics; active tectonics; remote sensing

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1. Introduction

The Himalaya is formed as a result of the inter-continental collision between the Indo and Eurasian plates. The continuous northward movement of the Indian plate resulted in increased seismic activity in the Himalayan region. The convergence of tectonic plates has resulted in crustal shortening, formation of fault/thrusts and active tectonics in the Himalaya [1]. The movement of hanging wall material over its footwall in the Himalaya has resulted in the migration of tectonic blocks towards the south. The movement of tectonic blocks due to active tectonic activities in the Himalaya is predominant, confirmed by earlier studies [2], suggesting a convergence rate of 10–15 mm/year and a slip rate of 13.8 ± 3.6 mm/year. Other reports on active tectonics [3] suggest a convergence rate of 10.79 ± 2.23 mm/year, slip rate of 12.46 ± 2.58 mm/year, and uplift rate of 6.23 ± 1.29 mm/year in the Dun region of Garhwal Himalaya and Kala Amb of Himachal Pradesh and [4] proposed a movement of 15 mm/year across the Kumaun-Garhwal Himalaya.

Several authors envisage that the movement of tectonic blocks influences the geomorphology of the Earth's surface and the development of drainage networks [5–7]. Additionally, the movement of tectonic blocks along faults has resulted in active tectonic activities in an area, and in turn, controls the behavior and development of drainage features [8]. Geomorphic features are the manifestations of the landscape evolution of a basin and thus are often utilized for the quantitative and qualitative assessment of tectonic

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The 23rd April '21 Snow Avalanche, Girthi Ganga post the 7th February '21 Rishi Ganga Flash Flood: Are these Events Linked to Climate Warming in the Western Himalaya?

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ABSTRACT

The upper catchment of Dhauli Ganga valley (Chamoli district) in Uttarakhand Himalaya recently witnessed a large snow avalanche on the night of 23rd April 2021 along the Indo-Tibet border. This event followed the 7th February 2021 Rishi Ganga (debris flow induced) flash flood within less than three months. This note analyses the plausible causes of the avalanche using pre-disaster field survey data, supported by the limited geological and remote sensing based geomorphological investigations as the site could not be investigated due to remoteness of the location and travel restrictions due to COVID pandemic. The present observations suggest that active and relict cirques to the north of the South Tibetan Detachment System (STDS) are the sites for potential snow and debris avalanches under the projected warming trends in the western Himalaya. Particularly, the study calls for climate change adaptation measures in the climate sensitive Trans Himalayan region and optimize anthropogenic activities in order to safeguard the lives and vital infrastructure.

INTRODUCTION

The recent 7th February 2021 Rishi Ganga (debris-flow) flash flood, and the large snow avalanche of 23rd April 2021 in the Girthi Ganga valley near the Indo- Tibet border occurred in the upper Dhauli Ganga catchment (>3500 m asl). The steep terrain, seismicity, fragile geological formation, and intense and highly variable precipitation trends, make the region vulnerable to floods, landslides, avalanches, and, debris flows (Rawat et al., 2012; Vaidya et al., 2019). Geomorphologically, the valleys at higher elevations (>2500 m asl) are dominated by paraglacial processes that are directly conditioned by the modern glaciers and are constantly adjusting to changing glacier boundary conditions due to local and regional climate variability (Church and Ryder 1972). These valleys also sequester paraglacial debris left behind by the receding glaciers (Ali and Juyal, 2013) which can be mobilized by short-lived extreme weather event (Sundriyal et al., 2015). Thus, the paraglacial zones are not only ecologically fragile but are geomorphologically unstable due to constant re-sedimentation and transfer of glacial sediments (Barnard et al., 2004).

The vulnerability of the terrain is well appreciated for the extreme events such as flash floods, which are likely to increase in frequency by 10% and over 30% of the existing magnitudes in Uttarakhand Himalaya (UAPCC, 2014). Various studies indicate that the Himalayan region has also witnessed significant warming in the recent decades particularly at the higher elevation (Krishnan et al., 2019). For example, the warming trend over 2000 m asl during the early twentieth century was about 0.10 °C per decade, which later doubled to 0.32 °C per decade (Yan and Liu 2014). A more recent study by Sabin et al., (2020) suggested that the warming was more amplified over 4000 m asl (0.5 °C/decade). Also, in most parts of the Himalayan region, warming rate is reported to be more substantial in winter as compared to other seasons (Bhutiyani et al. 2007). The rising temperature directly influences the melting of glaciers, snow, and permafrost to generate cascading effects (Mool et al, 2011; Bolch et al., 2012; Wang et al., 2019). For example, degrading high-mountain permafrost increases the probability of rock ice/avalanches from steep slopes reaching glacial lakes and triggering Glacial Lake Outburst Floods (GLOFs) (Haeberli et al. 2016). Such hazards have severe implication for the people, and existing infrastructure, such as dams, bridges and roads.

The 23rd April 2021 Girthi Ganga snow avalanche destroyed the Border Road Organization's (BRO) temporary shelter camp for the labourers who were engaged in the strategically important Indo-Tibet border road construction. Available reports indicate that the avalanche claimed sixteen lives while 384 people were rescued. Considering the sensitivity of the Trans Himalayan terrain to snow avalanches, the study (i) analyses the plausible causes of the avalanche and (ii) explores the potential geomorphic features that most likely make the terrain vulnerable to such events under the projected climate trends. The geological and geomorphological investigations undertaken during pre-disaster field survey (2018) supported by the available aerial photograph, video and Google Earth imagery was used. Due to remoteness of the location and travel restrictions due to COVID pandemic, the site could not be visited after disaster.

STUDY AREA

The 23rd April 2021 avalanche occurred in the upstream of Malari village in the Girthi Ganga valley- a tributary of the Dhauli Ganga in the upper Alaknanda catchment. Geologically, the semi-arid/arid terrain lies in the rain shadow zone of the Higher Himalaya (Nanda Devi Massif; a World Heritage Site) (Fig.1). The Indian Summer Monsoon (ISM) is the major contributor of moisture during summer, while the subordinate contribution comes from the westerly disturbances during the winter months (Bisht et al., 2015). The Girthi Ganga river originates from Jandi Dhura (5900 m asl) - a cirque glacier and flows westward to meet Dhauli Ganga river near the Malari village. Observations from Google Earth imagery of the Dhauli Ganga watershed show that there are several relict and a few active cirques with steep slope profiles that are directly coupled with the Girthi and Dhauli Ganga river valleys (Fig.1). Presently, the Girthi Ganga valley slopes are barren and devoid of any large valley glaciers. The Dhauli Ganga valley however, has a few big glaciers (>5 km) such as Dunagiri, Kosa, Bagini, Bankund, Semkharak and Purvi Kamet (Fig.1). The bigger valley

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ARTICLE COMMENTARY

A call for reducing tourism risk to environmental hazards in the Himalaya

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ABSTRACT

As mountain tourism rapidly expands in remote landscapes, there is a critical need for improved disaster risk management to ensure the safety of tourists and industry workers, safeguard infrastructure designed to support tourism and service industries (e.g., transportation), as well as protect the local economies that have come to depend on tourism revenue. Drawing from recent disasters in the Himalaya, we present evidence that the promotion of safe and sustainable tourism is out of sync with the proliferation of inbound tourists who are prone to many types of environmental hazards. The key driver of this situation is commercialisation. Other factors include increased mobilities/access of tourists who are often unaware of or ill-prepared to cope with hazards; lack of regulations with respect to overcrowding, safety and building codes increased exposure to climate change phenomena; and limited disaster response capabilities, including responsibility at the local level. In this perspective we argue that this particularly complex situation is best addressed through the lens of a dynamic system, whereby strong leadership, increased regulation of access and participation, and enhanced professionalism via training are key leverage points in countering uncontrolled commercialisation that drives increased risk to known hazards. The inclusion of tourism into disaster risk management systems is also needed where hazard risks and tourist traffic are high, as tourists are part of the transient population who are often unfamiliar with local conditions and ill-prepared to cope with extreme adversity.

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tourism safety; hazard preparedness; climate change; mobility; access; overcrowding; commercialisation; systems dynamics

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ORIGINAL ARTICLE

Assessment of soil erosion, flood risk and groundwater potential of Dhanari watershed using remote sensing and geographic information system, district Uttarkashi, Uttarakhand, India

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Abstract

Quantitative morphometric analysis of Dhanari watershed has been done using remote sensing and Geographical Information System (GIS). The impact of climate, lithology, tectonics, structural antecedents, vegetation cover and land use on hydrological processes is assessed by quantifying geomorphic parameters. The Dhanari River (a tributary of the Bhagirathi River) and its tributaries Dhanpati Gad and Kali Gad forms Dhanari watershed covering 91.8 Km^2 area. Several geomorphic aspects viz. linear, areal, relief were computed to comprehend potentials of soil erosion, groundwater, flood vulnerability and the geomorphic response of watershed. LISS-III image is used to generate the Land Use and Land Cover (LULC) map and assess the watershed dynamics. Values of computed hypsometric integral and morphometric parameters viz. drainage density (D_d), stream frequency (F_s), stream length ratio (L_{ur}), bifurcation ratio (R_b), rho coefficient (ρ), drainage texture (D_t), circularity ratio (R_c), relief ratio (R_{hl}), elongation ratio (R_e), form factor (F_f), basin shape (B_s), drainage intensity (D_i), compactness coefficient (C_c) and infiltration number (I_f) have shown a moderate and steady erosion rate, with low groundwater potential and low to moderate flood vulnerability in the watershed. Hypsometry presents a dependable geomorphic parameter to understand the erosion and geomorphic response of a watershed to hydrological processes. Hypsometric integral value (0.51) of Dhanari watershed suggests a mature topography with steady erosion in the watershed.

Keywords Morphometry · Dhanari watershed · GIS · Remote sensing · Hypsometry · Vulnerability · Groundwater · Erosion · Flood

Introduction

Himalayan mountains have one of the most complex and dynamic drainage systems. The rivers and their tributaries are important geographical units in the region as they are the primary source of fresh water in most parts of the Himalaya. The river and streams also act as driving forces for any ongoing fluvial activity. The fluvial activities play a vital role in shaping and modifying the landforms of the Himalayan terrain. In Dhanari watershed, the population relies on surface runoff water for their need for freshwater; as the groundwater resources in the Dhanari watershed are sparse, most of the watershed population resides along the river and its tributaries. The area residents are practicing agricultural activities in the loose and fertile alluvium of the Dhanari River and its tributaries. The Dhanari watershed is highly susceptible to soil erosion as heavy rainfall occurs during pre-monsoon and monsoon season (average annual rainfall of 1693 mm), increasing the surface runoff. It becomes necessary to have proper watershed management plans to check the soil loss during any watershed management activity. It is essential to understand the hydrological nature of rocks before morphometric analysis (Singh et al. 2014).

Morphometric assessment of earth surface, shape and landforms is done by quantitative measurement and numerical analysis (Clarke 1966; Biswas et al. 2014). Morphometric analysis methods were introduced by Horton (1932, 1945) to present its relationship with the natural agents like

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ORIGINAL PAPER

Coseismic landslide hazard assessment for the future scenario earthquakes in the Kumaun Himalaya, India

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Abstract

The coseismic landslide is one of the important hazard phenomena in the hilly and seismically active mountainous region. It is, therefore, essential to map the areas susceptible to coseismic landslides, especially for the seismically active region.

In the present work, the probabilistic assessment of coseismic landslides has been carried out for Goriganga valley located in the Kumaun Himalaya, India, which lies in the highest seismically active zone of the seismic zoning map of India. Several studies suggest that this region is prone to a great future earthquake of Mw ≥8.0.

In this context, mapping of the coseismic landslide has been made for the future scenario earthquakes of 7.0, 8.0, and 8.6 Mw using modified Newmark's analysis. The modified Newmark's analysis provides the permanent displacement of the potential landslide, by integrating (1) joint strength of rock mass, (2) critical acceleration of the slope, and (3) peak ground acceleration of the region. Newmark permanent displacement has been estimated, which provides the distribution of predicted slope failure in the area.

It has been observed that 41% of the area exhibits >40 cm Newmark's permanent displacement corresponding to Mw 8.6 earthquake and thus susceptible to failure, followed by 8.0 and 7.0 Mw earthquake with 36 and 14% of the area susceptible to the coseismic landslide, respectively. Further, the maximum permanent displacements for the simulated earthquakes of Mw 7.0, 8.0, and 8.6 are 76, 279, and 502 cm, respectively.

Keywords Coseismic landslide · Himalaya · Dynamic slope stability · Newmark analysis · Seismic

Introduction

Landslides are caused by numerous geological, geomorphological, and anthropogenic factors but are generally triggered by rainfall and earthquake vibrations (Cruden 1991; Haque et al. 2019). In the tectonically active mountainous terrains, earthquake is one of the major triggering factors for the occurrence of landslides (Keefer 1984; Youd 1985; Jibson et al. 2000; Xu et al. 2013), and many a time, it has been noticed that the destruction caused due to the earthquake-induced landslides is much greater than the destruction caused by direct ground shaking of an earthquake (Keefer 1984; Jibson et al. 2000; Dunning et al. 2007). These landslides cause immense loss of lives and damage to lifeline infrastructures such as water and gas pipelines, schools, and hospitals, roads, and drainage; hence, these kinds of landslides are one of the most important geohazards in the seismically active hilly region. For examples, the 1999 Chi-Chi, Taiwan earthquake (M_w = 7.6) triggered >9272 landslides, which cause several causalities and damage to the infrastructure (Lin and Tung, 2004), and the 2008 Wenchuan, China, earthquake (M_w = 7.9) triggered >15,000 landslides, killing ~20,000 people, and this accounts for one-fourth of the total deaths due to the earthquake (Yin et al. 2009).

Earthquake-induced landslides are very common in the Himalaya and its surrounding regions. There are many recent examples of earthquake-induced landslides from the Himalayan terrain, such as the 2005 Kashmir earthquake (M_w = 7.6) triggered 2424 landslides (Owen et al. 2008), 2011 Sikkim earthquake, India (M_w = 6.9) triggered 1196 landslides (Martha et al. 2015), the 2013 Lushan, earthquake, China (M_w = 6.6) triggered 4540 landslides (Ma and Xu 2019), the 2014 Ludian earthquake, China (M_w = 6.1) triggered 1826 landslides (Zhou et al. 2016; Chen et al. 2019),

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Large scale geological mapping and slope stability analysis of the pilgrimage route between Sonprayag and Kedarnath, Uttarakhand, India

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Abstract: The slope instability is a major geotechnical challenge in Himalaya which often disrupts the socio-economic environment of Uttarakhand state. Mandakini valley of the Uttarakhand, along with many others, evidenced an unprecedented disaster as a consequence of flash-flood and landslide during June 2013. This event highlighted many geological, environmental and anthropogenic issues that aggravated the severity of this disaster. One of the most vulnerable infrastructures is the roadways, which further invites systemic vulnerability to society. The National Highway 107 connects one of the remotest tourist hotspot Kedarnath with the rest of the country and hence, serves as a lifeline infrastructure to thousands of tourists and local inhabitants. This highway along with a foot track between Sonprayag and Kedarnath was worse affected during June 2013, cost thousands of lives. The slope-instability of a region can be mitigated up to great extent by adequately handling the geo-environmental and geotechnical factors. We carried a detail geological and geotechnical investigation of the area to perform the slope stability analysis using the Slope Mass Rating (SMR) and Rock Mass Rating (RMR) scheme. We identify several locations which are prone to planner, wedge or both type of failure.

Keywords: : Mandakini Valley, landslide, Kedarnath, Kinematic Analysis, RMR, SMR, Slope stability.

INTRODUCTION

Slope instability is a major problem throughout the Himalayan region. Moreover, landslides are frequent and large in dimension in the Main Central Thrust zone (MCTZ) of Garhwal Himalaya, which are often triggered by the monsoon rain (Valdiya 1987, 2014; Bhatt 1992; Kimothi *et al.* 1999). In the recent past, the Mandakini valley of Garhwal Himalaya witnessed many landslides tragedies viz.1998 Bhenti-Paundar (Bist & Sah 1999; Bhandari 1999; Rautela & Thakur 1999), 2001 Phata-Byung (Naithani *et al.* 2002; Chaudhary *et al.* 2008, 2010), 2012 Okhimath (Martha 2013; Islam *et al.* 2014; Rana *et al.* 2014) and 2013 Kedarnath. Among these, the Kedarnath flash-flood was one of the most devastating events in the recent history of Uttarakhand.

The geomorphological setup of the area consists mainly of moraines; reworked moraine, debris flow, colluvial fan, and glacial outwash plain are very sensitive to any change of the climate. In 2013 numerous new landslides were generated and many old landslides were reactivated as a consequence of torrential rain and toe erosion in the Mandakini Valley (Bhambri *et al.* 2017; Poonam *et al.* 2017). These landslides caused unprecedented damage to lives and infrastructures, especially to the roads network. It has been argued that the frequency of the landslide activities has increased with the increase in infrastructure development activities (Pradhan *et al.* 2018). Therefore, it was suggested that adequate consideration of geology and geomorphology along with the appropriate engineering techniques is a necessary step towards landslide mitigation (Sati *et al.* 2011). Although the slope stability analysis provides significant clues towards evaluating the slopes for potential failure mechanism and mitigation countermeasures, the high resolution geological and structural field data from harsh climatic reaches is lacking for such analysis. In this study, we provide a detailed account of geological, structural and geomorphological data for a highly vulnerable zone along with the slope stability analysis to identify the active and potential failure zones, mode of failure in rock slopes and triggering factors for slope sensitivity between Sonprayag and Kedarnath. The stability of a slope can assess quickly and reliably through rock mass classification system; Rock Mass Rating (Bieniawski 1973) and Slope Mass Rating (Romana 1985). These classification systems use a defined number of parameters, to which ranges of value are assigned, based upon in-situ surveys, or laboratory and field tests. Many researchers have used these methods to assess the slope stability in different part of Garhwal Himalaya (Anbalagan 2008; Kimothi *et al.* 2010; Umrao *et al.* 2011; Sarkar *et al.* 2012a; Singh *et al.* 2013; Gupta 2014, 2017; Vishal *et al.* 2015a, 2017; Siddique *et al.* 2015, 2017; Kumar *et al.* 2019; Chaurasia *et al.* 2017; Chauhan *et al.* 2018).

STUDY AREA

The study area is located in the Rudraprayag district of the Uttarakhand State; India. This includes a 5km long portion of National Highway (NH-107) i.e. from Sonprayag to Gaurikund and after that 18km foot track to the Kedarnath shrine (3500 m) in the Mandakini valley (Fig. 1). Along this route, Sonprayag and Gaurikund are the densely populated villages located at the right bank of the Mandakini River. These villages are the main halt of this pilgrimage route and worse affected during the 2013 flash flood disaster (Asthana & Asthana 2014; Sundriyal *et al.* 2015). Upstream to the Gaurikund village, the Ganesh Chatti, Jungle Chatti, Bhimbali, Rambara, Lincholi and Rudra point are the main locations of halt along this track. These locations are highly prone to landslide hazard due to steep slope and highly unconsolidated glacial and debris sediments. The Kedarnath town is also located on glacial deposits.

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A preliminary assessment of the 7th February 2021 flashflood in lower Dhauli Ganga valley, Central Himalaya, India

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A short-lived flashflood in Rishi and Dhauli Ganga rivers on 7th February 2021, Uttarakhand Himalaya, killed 65 people with 141 reported missing (official estimate) and devastated two hydropower projects. Geomorphological observations supported by meteorological data suggest that the flood was triggered by a combination of avalanche and debris flow. The Dhauli Ganga valley has preserved ponded sedimentary sequences (laminated sand and silty-clay), suggesting that the valley is prone to episodic mega foods in the recent geological past. Considering that the receding glaciers in the higher Himalaya have left behind enormous sediment, unusual weather events are likely to generate such disasters more frequently as the climate becomes warmer. Thus, the study calls for not only incorporating the disaster risk assessment in the developmental planning of the Himalayan region but also recommends routine monitoring of the potential areas of structural failures in the glaciated valleys along with supra-glacial lakes.

Keywords. Flash-flood; Dhauli Ganga; Rishi Ganga; Garhwal Himalaya.

1. Introduction

The retreating glaciers of the Hindu Kush Himalayan (HKH) region are geomorphic expression of the current climate warming (Armstrong 2010). Also, there are growing number of proglacial and supra-glacial lakes which have the potential to generate high magnitude floods. However, the impact of a flood would depend on the physical characteristics of the moraine dam, the lake size and the stream gradient (Ives *et al.* 1986; 2010). Since the lakes are formed at higher elevations, the downstream impact is going to be severe due to extremely rapid debris flows. The breaching and associated flashfloods are called Glacial Lake Outburst Floods (GLOFs). It is being observed that glacial hazards (e.g., GLOFs, ice avalanches, and debris flows) caused due to accelerated glacial thinning and retreat are causing severe damage in populated HKH regions (Ives *et al.* 2010). There is a growing concern that with the rise in global temperature, their frequency and magnitude would

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Hydrological Characteristics of 7th February 2021 Rishi Ganga Flood: Implication towards Understanding Flood Hazards in Higher Himalaya

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ABSTRACT

A flash flood that originated from Raunthi Gad-a tributary of the Rishi Ganga river, in Garhwal Himalaya, caused unprecedented loss to lives and damaged two hydropower projects on 7th Februray 2021. In order to asses the flood magnitude, the flow parameters of the flood were calculated using the super-elevation of the flood marks preserved in the flood affected valleys.

The textural characteristics of the flood deposits in the upper reaches of the valleys indicate dominance of debris flows. The peak discharge upstream of the confluence of Rishi Ganga and Dhauli Ganga was around $1.1x10^5$ m^3/s, which was four order of magnitiude higher than the normal peak discharge (~ 3 m^3/s). The flow achieved a velocity of 30±3 m/s. An exponential reduction in the flow velocity (from ~37 to 2 m/s) with distance is observed. For which the river gradient and increase in sediment load is implied flow that along its entrained way downstream between Raini and Tapovan. Considering the sensitivity of paraglacial zones to climate change, the paper calls for detailed studies pertaining to the response of paraglacial zones to extreme weather events. Importnatly, it is necessary to have more hydrological data covering multiple valleys for predictive model simulation of the nature and magnitude of such disasters in future.

INTRODUCTION

India stands among the six most flood-affected countries in the world (Luo et al., 2015). Floods in Himalaya are generally produced by extreme precipitation events (e.g. Sah et al., 2003; 2010; Juyal, 2010; Rana et al., 2012), landslide lake outburst floods (LLOFs) (Wasson et al., 2013; Rana et al., 2013), and the glacier lake outburst floods (GLOFs) (Korup et al., 2006) or due to the meteorological disturbances (Srivastava et al., 2017; Kale, 2004; Ziegler et al., 2014) or the combination of the above factors. The June 2013 Kedarnath flash-flood was triggered by a combination of high rainfall, snowmelt and subsequent Chorabari lake outburst (Sati and Gahalaut, 2013; Rana et al., 2013; Doval et al., 2013). It has been observed that debris flow triggered by high intensity rainfall events from paraglacier zones are one of the major factors responsible for devastating the infrastructures in the Higher Himalaya (Sundriyal et al., 2015).

The upper Alaknanda river catchment is dominated by the glacial and paraglacial processes in which the Rishi Ganga, a tributary of Dhauli Ganga, contains the largest concentrations of glaciers. (Fig. 1). On 7th February 2021, at around 10:30 a.m. a debris laden flash flood originated from Raunthi Gad -a tributary of Rishi Ganga. The flood water devastated a 13.2 MW hydropower project at Raini village taking at least 80 lives. Further downstream, in the Dhauli Ganga valley, it destroyed an under-construction barrage of 520 MW hydropower project and killed nearly 150 people (either swept away or buried/trapped in the tunnel).

From future risk assessment point of view, this flood raised two important questions: (i) what was the process responsible for the genesis of the debris-laden flash flood from a small stream? (ii) What determined the pattern of damage in the valley? To address these questions, hydrological parameters are employed for determining the magnitude and characteristic of this flood as it moved down valley. The geomorphic imprints left behind by the flood are documented by using the total station to reconstruct pre- and post-flood scenarios with respet to channel geometry. Further, the hydrological characterization of the flood was done using empirical methods (for calculating flood velocity and discharge).

STUDY AREA

The Rishi Ganga catchment (area ~690 km^2) is located in the Garhwal region of Central Himalaya, India (Fig.1). The Rishi Ganga river, a sub-tributary of the Alaknanda river, emanates from the group of glaciers in the Nanda Devi Biosphere Reserve (NDBR) and joins Dhauli Ganga river near Raini village. The elevation in the catchment ranges from ~1930 m above mean sea level (a.m.s.l.) at the confluence to 7817 m a.m.s.l (Nanda Devi). The glaciers cover ~25 % of the total area of this basin. It hosts seven major valley glaciers of varying length ranging from 5 to 10 km (Kumar et al., 2020) including a few hanging glaciers and cirques (Fig.1). According to glacier inventory (RGI Consortium, 2017), ~74 glaciers having areas from 0.02 km^2 to 33.5 km^2(with an average area of 2.3 km^2) are located in this basin. Among these eight large glaciers (area>5 km^2) cover 72% of total glaciated area. The major concentration of the glaciers feed the east-west flowing stream, while the Raunthi (Bank) glaciers contribute to the northward-flowing Raunthi Gad (Gad - stream).

The Rishi Ganga valley is characterized by recent glacial deposits in the form of moraines. Apart from the moraines, significant amount of debris is available in the form of scree cones emerging from the cirques and slope failures (Fig.1). The channel gradient is steep (10^{-1}), to moderate (10^{-2}) and the average hill slopes ranges from

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Climate-tectonic imprints on the Late Quaternary Ravi River Valley Terraces of the Chamba region in the NW Himalaya

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ABSTRACT

An attempt has been made to reconstruct the landform evolution in monsoon-dominated the Ravi River Valley (a major tributary of the Indus River), Chamba Nappe, Lesser Himalaya based on detailed field mapping, supported by the Optically Stimulated Luminescence (OSL) dates. In the upper Ravi River Valley sediments are generated by glaciation-paraglaciation processes and accumulated in terraces and alluvial fan deposits in lower reaches north of the Main Central Thrust during deglaciation and periods of intensified monsoonal phases. Field study and OSL dating demonstrate aggradation of river terraces and debris-flow terraces occurred in two major phases: 73–46 ka and 39–23 ka and at least six minor phases between <23 ka and 7 ka. The incision was initiated shortly after 7 ka and ascribed to the decrease in overall monsoon intensity and simultaneous reduction in sediment flux. The first phase (73–46 ka) of aggradation was regional and occurred in a pre-existing river valley, whereas the later phases (39 ka onward) occurred as cut-and-fill and degraded terraces. The incision of the first major phase (220 m thick) accelerated between ~46 ka and 39 ka due to reactivation of the Chamba Thrust and the Main Boundary Thrust (MBT). The study suggests that the fluvial dynamics and aggradation phases in the Ravi River Valley were regulated by monsoon variability, whereas both tectonic activity and climatic variables governed the incision of these deposits. The contemporaneous aggradation and incision in the hinterland and the Indo-Gangetic plains suggest that the Late Quaternary climate variability was the main factor in the evolution of fluvial landforms.

1. Introduction

Erosion and aggradation by rivers have played a major role in sculpting the Himalayan landscape (Thiede et al., 2005; Eugster et al., 2016), forming river terraces in the mountain valleys (Bookhagen et al., 2006; Kumar and Srivastava, 2017; Chahal et al., 2019; Thakur et al., 2020; Kumar et al., 2020) and alluvial fans in the Indo-Gangetic Plains (Srivastava et al., 2003; Gibling et al., 2005, 2008). These landforms serve as indicators of climatic perturbations (Ray and Srivastava, 2010; Dutta et al., 2012; Chahal et al., 2019) and tectonic uplift (Thakur et al., 2014, 2020). Sediments generated and transported by the Himalayan rivers are mainly governed by glacial-deglacial processes (Owen et al., 2005, 2008; Juyal et al., 2010; Eugster et al., 2016) and strengthening of the Indian Summer Monsoon (ISM) and the westerlies (Bookhagen et al., 2005a; Gibling et al., 2005).

The large river systems of the Indus, Ganges and Brahmaputra drain the climo-tectonically active Himalayan Range. The Satluj, Beas, Ravi, Chenab, Jhelum and Indus are the principal rivers of the Indus system. These rivers carry vast amounts of sediment from the mountain range to the Arabian Sea (Fig. 1a) (Clift et al., 2001, 2002; Inam et al., 2007). Glaciation, landslides and fluvial erosion are major denudational processes in the NW Himalaya (Owen et al., 2008; Bookhagen et al., 2005a, b, 2006; Dey et al., 2016). The sudden rise in topography acts as orographic effects in the Himalaya, which influences the spatial distribution of monsoon rainfall and therefore focused erosion rates (Thiede et al., 2005), thus generating voluminous sediment for down valley aggradation. In the NW Himalaya, the Siwalik foothills have a height of 750 m, still only 10 km to its north, the Dhauladhar Range (D-range) reaches a maximum height of 5500 m causing an altitudinal zonation of climatic and geomorphic regimes (Srivastava et al., 2009; Thakur et al., 2014, 2020) (Fig. 1b).

Low-temperature thermochronology across the D-range, the Pir

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Reconstruction of active surface deformation in the Rishi Ganga basin, Central Himalaya using PSInSAR: A feedback towards understanding the 7th February 2021 Flash Flood

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Abstract

Active surface deformation, displacement pattern, and erosional variability is estimated using the geomorphologically sensitive morphometry along with the Persistent Scatterer Interferometric Synthetic Aperture Radar (PSInSAR) technique using the Sentinel-1Adata (119 images) acquired between 07- 02-2017 and 10-02-2021. The average velocities for this dataset are estimated to be between ±11 mm/y. The Raunthi River catchment from where the flood was triggered is undergoing ~8 mm/y subsidence and ~10 mm/y uplift. Compared to this the basin wide deformation (Rishi Ganga basin) is estimated to be around ±10 mm/y with commulative ground displacement of around ±45 mm. The times series analysis suggests an increase in the ground displacement by around 5 mm/y and seems to be responsible for the expansion of pre-existing cracks in the vicinity of the Vaikrita Thrust (VT) and subsequent failure of the northern face of Nandi Peak on 7th February 2021. The Global Positioning System (GPS) derived strain distribution pattern indicate a relatively higher accumulation of strain (>0.35μ strain/y). The normalized steepness index (k_{sn}) variation along the longitudinal section of Rishi Ganga and Raunthi River sub-basin in Central Himalayan region shows anomalous increase at the glacio-fluvial transitional processes. Moreover, the χ profiles as well as planform plots shows anomalously lower values within the Raunthi River sub-basin when compared with the Rishi Ganga basin. Based on the lower values of χ it is observed that Raunthi River sub-basin is undergoing high erosion which can be caused by the presence of sheared lithology and incision of the relict glacial and paraglacial sediments. We negate the suggestion that abrupt rise in the temperature was the major triggering mechanism for the recent disaster, instead it is the sheared lithology and pre-existing fissure developed because of differential uplift and subsidence in Raunthi River that led to the wedge failure and subsequent flash flood. Had the climate was the major driver of the recent tragedy ?, it should have impacted multiple hanging glaciers in the Rishi Ganga valley. Therefore, the study calls for detailed geomorphological, structural and glaciological investigation in regions dominated by glacial and paraglacial processes in the strategic regions of the Himalaya. Towards this, the state of art PSInSAR technique seems to provide fast and reliable detection of terrain instability/stability along with identification of potential areas of slope failures in near future in the glacial and preglacial zones.

Keywords: Rishiganga; Flash flood; Crustal deformation; PSInSAR; Central Himalaya

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Indian summer monsoon variability during the last 20 kyr: Evidence from peat record from the Baspa Valley, northwest Himalaya, India

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We present millennial to centennial-scale monsoon variability during the Late-Pleistocene to Holocene using multi-proxy data from 100 cm thick peat deposit in the Baspa Valley, northwest Himalaya. Based on high-resolution mineral magnetism, carbon isotope, and total organic carbon data supported by radiocarbon dating, four climatic phases of alternating strengthened and weakened Indian summer monsoon (ISM) are identified for the last 20 kyr in the higher central Himalaya. Periods of strengthened ISM are dated to ∼15 to ∼14 ka, ∼10 to ∼7 ka, ∼2.4 to ∼1.3 ka, and 243 yr BP to present, which is ascribed to the post-Older Dryas associated with an increase in solar insolation. The phases of weakened ISM are bracketed between ∼20 and ∼15 ka, ∼14 to ∼10 ka, ∼7 to ∼2.4 ka, and ∼1300 to ∼243 yr BP. These phases are attributed to global cooling events, i.e., the Last Glacial Maximum (LGM), Younger Dryas (YD), and the Middle to Late Holocene. They govern by changes in the solar insolation.

Keywords. Indian summer monsoon; northwest Himalaya; carbon isotope; environmental magnetism; radiocarbon dating.

1. Introduction

The ISM is an important component of the tropical climate system coupled with the global atmospheric circulation driven mainly by the land–sea thermal contrast (Colin *et al.* 1998; McGregor and Nieuwolt 1998; Zhang and Wang 2008). During the boreal summer, warming leads to the development of low-pressure zone in the Indian subcontinent instigating moisture-laden winds to blow from the sea to the landmass, thus squeezing the moisture from the sea towards the land, whereas reverse happens during winter when continental winds become stronger (Prell and Kutzbach 1992; Zhang and Wang 2008). The Himalaya receives most of the precipitation from the ISM, and the Middle-latitude Westerlies (MLW) during the course of the year, and the influence of these weather systems varies spatially (Benn and Owen 1998). Most of the southern and eastern Himalaya experience pronounced summer precipitation along (W–W) and across (S–N) of the Himalaya. During the winter, MLW is the major contributor to the precipitation in the western part of the Himalaya as its intensity decreases eastward (Benn and Owen 1998; Owen 2009). There is growing evidence to

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An integrated assessment of the geomorphic evolution of the Garhwal synform: Implications for the relative tectonic activity in the southern part of the Garhwal Himalaya

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The geomorphic changes over the earth's crust are influenced by tectonic activities. These geomorphic changes are remnants of deformation that occurred in the recent geological past. Geomorphic features can be quantified to assess relative tectonic activity and response of landscape to active tectonics, regional structures, lithology and climate. To achieve the objectives, we evaluated the relative tectonic activity of the Garhwal synform, for which six major river basins were selected. The relative tectonic activity of all the basins is computed based on quantitative analysis of geomorphic indices. Quantitative analysis of each geomorphic parameter has been carried out, and a combined product of relative tectonic activity index (TAI) was derived for each basin. The TAI is classified into three classes based on their relative tectonic activity; basins having TAI value $\leq$1.75 (basins I, II and III) are placed in very high tectonic activity class, basin with a value ranging >1.75 to <2.0 are categorised as moderately active basins (basin 'IV'), while basins having values >2.0 are less active (basins V and VI). A relative tectonic activity map of the area suffices for the prioritisation of each basin based upon their TAI. Furthermore, analysis of the longitudinal profile of rivers for knickpoint, precipitation and temperature variability over the last 100 years and seismic events since the last 100 years have been studied to interpret the tectonic regime and their influence on landscape evolution. The regional seismicity data suggest that the area falls in a seismic gap and has not experienced a great earthquake in recent history but have received seismic events of moderate intensity in the past. We opine that the Garhwal synform is tectonically active, and thus, significant steps should be taken for seismic risk assessment along with preventive measures. We also suggest that the influence of tectonic activities in the southeastern part of the Garhwal synform comprised by basins V and VI is relatively less than the rest of the basins. Finally, the six basins were prioritised based on their relative tectonic activity.

Keywords. Garhwal Himalaya; geomorphology; remote sensing and GIS; quaternary geology; geomorphic indices; relative tectonic activity; prioritisation.

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Late Pleistocene–Holocene flood history, flood-sediment provenance and human imprints from the upper Indus River catchment, Ladakh Himalaya

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ABSTRACT

The Indus River, originating from Manasarovar Lake in Tibet, runs along the Indus Tsangpo suture zone in Ladakh which separates the Tethyan Himalaya in the south from the Karakoram zone to the north. Due to the barriers created by the Pir-Panjal ranges and the High Himalaya, Ladakh is located in a rain shadow zone of the Indian summer monsoon (ISM) making it a high-altitude desert. Occasional catastrophic hydrological events are known to endanger lives and properties of people residing there. Evidence of such events in the recent geologic past that are larger in magnitude than modern occurrences is preserved along the channels. Detailed investigation of these archives is imperative to expand our knowledge of extreme floods that rarely occur on the human timescale. Understanding the frequency, distribution, and forcing mechanisms of past extreme floods of this region is crucial to examine whether the causal agents are regional, global, or both on long timescales. We studied the Holocene extreme flood history of the Upper Indus catchment in Ladakh using slackwater deposits (SWDs) preserved along the Indus and Zanskar Rivers. SWDs here are composed of stacks of sand-silt couplets deposited rapidly during large flooding events in areas where a sharp reduction of flow velocity is caused by local geomorphic conditions. Each couplet represents a flood, the age of which is constrained using optically stimulated luminescence for sand and accelerator mass spectrometry and liquid scintillation counter ^{14}C for charcoal specks from hearths. The study suggests occurrence of large floods during phases of strengthened ISM when the monsoon penetrated into arid Ladakh. Comparison with flood records of rivers draining other regions of the Himalaya and those influenced by the East Asian summer monsoon (EASM) indicates asynchronicity with the Western Himalaya that confirms the existing anti-phase relationship of the ISM-EASM that occurred in the Holocene. Detrital zircon provenance analysis indicates that sediment transportation along the Zanskar River is more efficient than the main Indus channel during extreme floods. Post–Last Glacial Maximum human migration, during warm and wet climatic conditions, into the arid upper Indus catchment is revealed from hearths found within the SWDs.

INTRODUCTION

Large floods are a naturally occurring phenomena that contribute to landscape evolution by eroding mountain drainages and creating fertile floodplains in the lowlands where sedimentation occurs. According to a recently published report by the United Nations Office for Disaster Risk Reduction (2020, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiIirC0vqDvAhWJWisKHUv9D8QQFjAAegQIAhAD&url=https%3A%2F%2Fwww.undrr.org%2Fmedia%2F48008%2Fdownload&usg=AOvVaw3jVRNv8w_YYu2c-QI5qNonN), floods account for 44% of all disasters impacting 1.4 billion people worldwide with the two most populous countries, India and China, being affected the most.

Data from the Central Water Commission of India (CWC, 2012, http://cwc.gov.in/publications) shows a total economic cost of floods in India between 1953 and 2011 was US$ 6912 × 10^7 (more than US$ 69 billion). Floods in the Garhwal Himalaya in June, 2013, for example, claimed at least 6000 lives (Ziegler et al., 2014) and more recently, on 7 February 2021, a flash flood in the Chamoli District of the Garhwal Himalaya claimed more than 30 lives leaving more than 150 missing. A major flood event in the month of August in 2010 in Leh, NW Himalaya, killed ~1000 people (Juyal, 2010; Hobley et al., 2012; Ziegler et al., 2016). In most cases, these large floods are triggered by intense or long-duration rainfall (including cloud bursts), glacial lake outburst floods, landslide lake out bursts floods or combinations (Dimri et al., 2017). Outburst floods unrelated to meteorological conditions are common in the Himalaya owing to high density of glacial lakes. The Himalaya and its foreland and hinterland, consisting of a large part of Asia, are fed by three climatic systems: the Indian summer monsoon (ISM), westerlies, and the East Asian summer monsoon (EASM). Although, in the monsoon-dominated mountainous regions, floods are caused by abnormal precipitation arising out of tropical and extra tropical circulation interactions (Vellore et al., 2014, 2016; Priya et al., 2017). Similarly, a large part of China that is influenced by the EASM experiences on average 20 devastating floods per year (UNDRR, 2020, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiIirC0vqDvAhWJWisKHUv9D8QQFjAAegQIAhAD&url=https%3A%2F%2Fwww.undrr.org%2Fmedia%2F48008%2Fdownload&usg=AOvVaw3jVRNv8w_YYu2cQ-I5qNonN). The foregoing underscores a need for

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Original Article

Mountain highway stability threading on the fragile terrain of upper Ganga catchment (Uttarakhand Himalaya), India

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Abstract: Roads are the most critical means of connectivity in Himalayan villages. However, the terrain is inherently fragile with varied geological, geomorphological, ecological, and climate regimes, that result in frequent slope failure and disruption in connectivity. The risk is further to be increased by extreme events-generated hazards, which are expected to rise in frequency and magnitude with ongoing climate change. Critical scientific intervention, however, can improve the sustainability of road networks. The present study attempts to

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Dam in Himalaya induces geomorphic disconnectivity during extreme hydrological event: Evaluating a case of 2013 Kedarnath Disaster

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The June 2013 disaster in Kedarnath hit the Mandakini–Alaknanda river valley, resulting in devastating floods. This study deals with the pre- and post-flood event changes in the channel morphology and aims to investigate the geomorphological processes under river management in the Alaknanda valley, NW Himalaya and how the hydroelectric reservoir may have impeded the natural impact of the disaster and created geomorphic discontinuity. This work analyses the spatio-temporal variations in channel morphology over the last decade 2010–2020, discussing the impact of 2013 extreme event; the role of gradient in morphological patterns in river basin system. It highlights how the channel parameters like the thalweg shifts, active channel width, and area under sedimentation responded, from headwaters to lower gradient Lesser Himalayan zones to the 2013 event and suggests that any positive changes in these parameters diminish soon after the reservoir. The study implies that the capability of the reservoir to adjust the sediment load of the event in its upstream is an immediate short-term effect, but brings out the fact that it creates a geomorphic disconnect in the channel between upstream and downstream channel reaches of the reservoir. This disconnect may have a negative impact on sediment storage and sediment–water routing of the river and should be factored into the dam design ensuring natural continuum of geomorphic processes. Further, the study argues that the terrain north of the Main Central Thrust (Higher Himalaya) should be kept free from major human interventions to reduce flood hazards.

Keywords. Extreme events; channel morphology; gradient; reservoir; dam.

1. Introduction

Himalaya is susceptible to hazards mainly because of its rugged topography, high relief, rainfall distribution, lithology, and complex geological structures, where any extreme event like high-intensity rainfall, flash floods, glacial lake outburst floods (GLOFs), landslide lake outburst floods (LLOFs) and an earthquake can trigger landscape changes (Wasson *et al.* 2013a, b; Ziegler *et al.* 2014; Veh *et al.* 2019; Panda *et al.* 2020; Sharma *et al.* 2021). In 2013, a cloudburst-driven lake breach event wreaked havoc in the Mandakini–Alaknanda valley of Uttarakhand (Sundriyal *et al.* 2015), which is considered as the largest hydrological extreme in the past millennium (Rana *et al.* 2013; Wasson *et al.* 2013a, b). The event resulted in devastating floods and landslides, discharging a huge quantity

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Mid to late Holocene climate variability, forest fires and floods entwined with human occupation in the upper Ganga catchment, India

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ABSTRACT

The present study attempts to understand the geomorphic response in the upper Ganga catchmen mid-late Holocene (neoglacial) climate variability. The study infers five major phases of millenni climate variability with centennial-scale inversions using geochemical and magnetic proxies fro Lesser Himalayan Lake sediments. Phase-1 (6–4 ka) is marked by enhanced precipitation (increased allochthonous contribution) under a stronger Indian Summer Monsoon (ISM). The pro reversal in the trend between ~5 and 4 ka includes global arid events such as 4.2 ka. Phase-2 (4– shows a declining precipitation/runoff (decreased allochthonous input) under declining ISM prominent dip after ~3 ka. After phase-2 the climate reversals are distinct and of shorter (cent duration. For example, in Phase-3 (2.2–1.4 ka) improved ISM is inferred; Phase-4 (1.4–1.0 ka) is by a sharp decline in the ISM, and Phase-5 (<1.0 ka) includes centennial-scale events of Medieval Anomaly (MCA) and the onset of Little Ice Age (LIA). The relative increase (decrease) in the concen of geochemical and magnetic proxies is indicative of strengthened (weakened) ISM where relative phases are in sync with the North Atlantic climate perturbations. We observed clustering of o dated flood events around 6.5, 4.5, 2.6, 1.4, 0.8, and 0.4 ka which corresponds to periods of moder thus, suggesting a coupling between warm-humid monsoon and relatively dry westerlies. The re higher concentration of micro-charcoal in the lake sediments indicates widespread forest fires 5.9–5.3, 4.5–4.3, 3.4–3.0, 2.0–1.5 and ~1 ka. Given the archaeological evidence of sedentary settl since ~3 ka in the upper Ganga catchment, the study speculatively argues anthropogenic forc forest fires after 3 ka. Further, the highest probability flood phases succeed the fire events and indicative of enhanced vulnerability of the catchment to floods due to vegetation loss (enhanced and surface runoff).

1. Introduction

The Indian Summer Monsoon (ISM) is a major component tropical climate system, including the Central Himalaya significantly impacts the earth surface processes (e.g., Juyal

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Identification of landslide-prone zones in the geomorphically and climatically sensitive Mandakini valley, (central Himalaya), for disaster governance using the Weights of Evidence method

Poonam Chahal [a], Naresh Rana [a], Parshant Kumar Champati ray [b], Pinkey Bisht [a], Dhirendra Singh Bagri [a], Robert James Wasson [c], Yashpal Sundriyal [a]

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Highlights

- The identification of landslide prone areas in climatically and geomorphically sensitive Mandakini valley is the focus.
- Unscientific anthropogenic activities in areas located nearby streams are highly landslide susceptible.
- Final Landslide Susceptible Zonation map is validated using post disaster landslides and accuracy of the model is 77%.
- If the model of our study found affective, it can be applied for other river valleys also.

Abstract

The entire Himalayan region is prone to disasters, with many people being vulnerable to hydroclimatic threats such as extreme rainfall-driven floods, glacial lake outburst floods (GLOFs), landslide lake outburst floods (LLOFs), and landslides triggered by rainfall. Landslides and floods are related, as the former cause the lakes that burst, and floods can undercut slopes and cause landslides. During the past 200years, landslides and floods caused by LLOFs in the Garhwal Himalaya have occurred in 1894, 1970, and 1978; but the most disastrous event, in terms of loss of life and economic impact, occurred in June 2013, which was a result of extreme rainfall in the Higher Himalaya and breaching of a moraine-dammed lake, very short-lived LLOFs, and rainfall-induced runoff and landslides. Outmigration from the area as a result of the 2013 event has caused anxiety about the future of the economy and also concerns about security of a state that has an

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Pattern of Holocene glaciation in the monsoon-dominated Kosa Valley, central Himalaya, Uttarakhand, India

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Highlights

- Four stages of glaciations were identified since late glacial to late Holocene.
- Glacial stages were preserved in the form of curvilinear moraine ridges.
- Glacier responded to the minor changes in the temperature and moisture.
- Evidence of Last Glacial Maximum and Little Ice Age has been observed in Kosa valley.

Abstract

Reconstruction based on the geomorphology, lateral moraine stratigraphy, and limited optical chronology indicate that the monsoon-dominated Kosa Valley experienced four glacial advances during the late glacial to late Holocene. The oldest and most extensive glaciation, which is termed as Raj Bank Stage-1 (RBS-1), is represented by the degraded moraine ridge. This glaciation remains undated; however, the chronology of outwash terrace gravel dated to 12.7±1.3 ka indicates that the RBS-1 probably represents the Last Glacial Maximum (LGM). The second glacial advance (RBS-2) is preserved as a curvilinear lateral moraine and is dated to 6.1±0.4 ka. The third glacial advance viz. RBS-3 is bracketed between 5.0±0.5 and 4.0±0.4 ka. Following this, the glacier receded in pulses that are represented by two distinct recessional moraines (RBS-3a and b). The forth glacial stage (RBS-4), which is dated between 2.2±0.2 and 1.6±0.2 ka, shows a pulsating recession and is represented by a prominent recessional moraine (RBS-4a). Whereas, presence of unconsolidated, poorly defined moraine mounds proximal to the glacier snout are ascribed as neoglacial advance corresponding to the Little Ice Age (LIA).

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Paleofloods records in Himalaya

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Highlights

- Paleoflood records in major rivers like the Indus, the Alaknanda-Mandakini and the Brahmaputra are explored.
- The chronology suggests that the Alaknanda-Mandakini Rivers experienced extreme floods during the Medieval Warm Phase.
- During the Holocene climatic Optimum, the floods in the Indus river were an order of magnitude higher than the modern.
- The Brahmaputra river valley experienced a megaflood during 8–6ka BP.

Abstract

We use paleoflood deposits to reconstruct a record of past floods for the Alaknanda-Mandakini Rivers (Garhwal Himalaya), the Indus River (Ladakh, NW Himalaya) and the Brahmaputra River (NE Himalaya). The deposits are characterized by sand-silt couplets, massive sand beds, and from debris flow sediment. The chronology of paleoflood deposits, established by Optically Stimulated Luminescence (OSL) and ^{14}C AMS dating techniques, indicates the following: (i) The Alaknanda-Mandakini Rivers experienced large floods during the wet and warm Medieval Climate Anomaly (MCA); (ii) the Indus River experienced at least 14 large floods during the Holocene climatic optimum, when flood discharges were likely an order of magnitude higher than those of modern floods; and (iii) the Brahmaputra River experienced a megaflood between 8 and 6ka. Magnetic susceptibility of flood sediments indicates that 10 out of 14 floods on the Indus River originated in the catchments draining the Ladakh Batholith, indicating the potential role of glacial lake outbursts (GLOFs) and/or landslide lake outbursts (LLOFs) in compounding flood magnitudes. Pollen recovered from debris flow deposits located in the headwaters of the Mandakini River showed the presence of warmth-loving trees and marshy taxa, thereby corroborating the finding that floods occurred

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Engineering Geological Evaluation of Kakoragad Small Hydroelectric Project, Uttarakashi District, Uttarakhand

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Abstract: *The proposed Kakoragad small hydroelectric project is a run of the river scheme, on Kakora River near Harsil in Uttarkashi district of Uttarakhand. The water will be diverted by an 18m long rectangular trench type weir at an altitude of ±2942m. The diverted water will be carried to the powerhouse through power tunnels over a distance of 1629m to produce 12.5MW of electricity. The whole project is located within the rocks of Vaikrita Group. This study includes detailed discussions on geological setting in addition to highlighting the anticipated Engineering Geological problems likely to be encountered during construction of the project. The rocks at the project site have been classified using Rock Mass Rating (RMR) system and also by Q-system in order to predict rock load and support requirements.*

Keywords: *Kakoragad small hydroelectric project, RMR, Q-system, in-situ stresses, remedial measures*

I. Introduction

The snow fed perennial rivers of Himalaya have huge hydropower potential. This non-exhaustible resource is an effective means to meet the rapidly rising energy requirements of the country. Several mega and micro scale hydroelectric projects are already functioning in the Himalayan region, while many more are under construction as well as planning stages across the Himalayan Rivers. The suitable location for Run-of-the-River Schemes (RORS), in Himalaya is a challenging task due to the fragility and high seismicity of the terrain. Since the terrain is highly sensitive environmentally, safe water conductor structures such as tunnels are more preferred as compared to open channels, which involve huge cuttings of the slope and other attendant environmental issues. These structures have minimum environmental problems, easy to construct and maintain with extremely high stability against earthquakes. The stability of underground openings is dependent on rock mass condition, in-situ stresses, support stiffness, size and shape of the cavity, method of construction and sequence of construction practice among other factors. In the present case, the Engineering Geological problems associated with the construction of a small hydropower project has been discussed. Here, the proposed rectangular trench type weir will help to ensure free flow of water without stagnating the water across the river course.

The Kakoragad small hydroelectric project is a Run-of-the river scheme (RORS) for power generation by exploiting the hydro power potential of the Kakora stream, a tributary of the Bhagirathi River. The project is situated near Harsil, about 75km from Uttarkashi towards Gangotri (Fig 1). The Kakora stream is a perennial stream, which originates from the snow clad mountains having a peak elevation of 5900m and flows in the south-west direction up to Harsil village, where it meets the Bhagirathi River. This Engineering Geological problems of this small hydroelectric project have been discussed with particular reference to five important project components namely diversion weir, water conductor system, forebay, penstock and powerhouse.

II. Geological Setting Of Project Area

The Kakoragad small hydroelectric project is situated in Higher Himalayan terrain of Garhwal Himalaya. The rocks exposed in and around the project site belongs to Vaikrita Group. The region has undergone high grade metamorphism resulting in the formation of Garnet-Quartz-Mica Granulite interbedded with Biotite-Mica Schist. The Biotite-Mica Schist shows trapped emplacements of anhedral to subhedral crystals of quartz. Thick debris cover could be seen all along the stretch of the Kakora stream from Harsil and further upstream up to the proposed weir site. However, a small patch of rock is seen at the proposed weir site. Debris materials mainly consisting of big rock blocks mixed with silty soil are present close to the valley face on the left bank near diversion site and desilting tank. At the diversion site, rocks show well developed foliations with less developed joints. Huge thickness of debris found at

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Engineering Geological Evaluation of Siyan Gad Small Hydroelectric Project, Uttarakashi District, Uttarakhand

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Abstract: *The proposed Siyan Gad small hydroelectric project is a run of the river scheme, on Siyan Gad River near Harsil in Uttarakashi district of Uttarakhand. The water will be diverted by a 6m high weir through a 2.72 km long power tunnel to a surface power house near Jhala village to produce 5 MW of electric power. The whole project is located within the rocks of Harsil Metamorphics of Vaikrita Group. This study includes detailed discussion and control measures for engineering geological problems likely to be encountered during construction or post construction period. The rocks at the project site are classified according to Rock Mass Rating (RMR) system and also by Q-system in order to predict rock load and support requirements.*

Keywords: *Siyan Gad small hydroelectric project, RMR, Q-system, in-situ stresses, remedial measures.*

I. Introduction

The Himalayan region is rich with perennial rivers, which are potential enough to meet the rapidly rising energy requirements, but construction of micro to mega hydroelectric projects are challenged by the fragility and high seismicity of the terrain. The stability of underground openings is dependent on rock mass condition, in-situ stresses, support stiffness, size and shape of cavity, method of construction and sequence of construction among other factors.

The Siyan Gad small hydroelectric project is a run-of-river scheme for generation of 5MW by exploiting hydro-power potential of Siyan Gad stream, a tributary of Bhagirathi River. The Siyan Gad stream is fed by rain, spring water and glacial ice melts. The small hydroelectric projects in general have five major components namely Diversion Weir, Water Conductor System, Forebay, Penstock and Power House. Location Map of the study area shown in Fig 1.

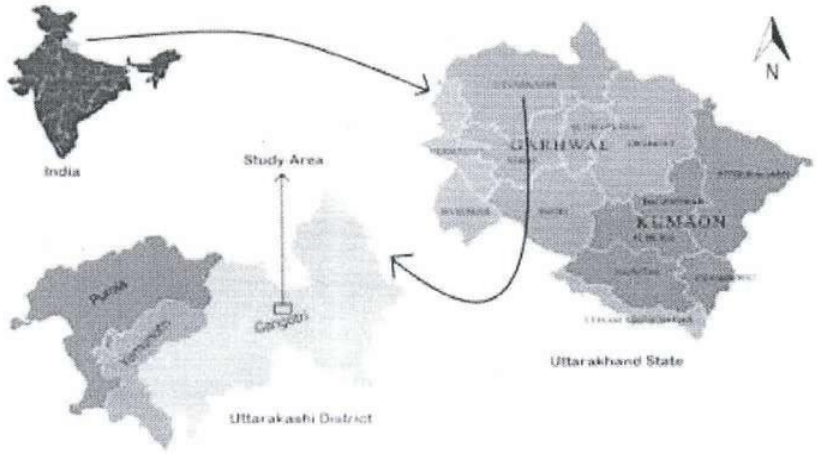

Fig.1. Location map of the study area

II. Geology of Project Site

The Siyan Gad small hydroelectric project is situated in Higher Himalayan terrain of Garhwal region. The rocks in the area belong to Vaikrita Group, named by Griesbach (1891). The medium to high-grade metamorphics of Vaikrita Group is known as Harsil Metamorphics. The lithology encountered in this area includes mainly micaceous quartzites, which consist of thick quartzite bands alternating with thin bands of mica schist. The mica bands mainly consist of biotite and muscovite minerals. Because of the presence of thick

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Kinematic analysis of slopes between Preng and Ganderbal, Jammu and Kashmir Himalaya, India

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Abstract: Slope stability is a matter of concern for many projects such as buildings, bridges, hydro projects, highways, railway, canal and tunnels in hilly terrain. The present study is carried out between Preng and Ganderbal in Ganderbal district of Jammu and Kahmir. The Ganderbal hydro project is located on the left bank of the river Sind. The Sind River is one of the tributaries of Jhelum River. Slope Mass Rating (SMR) has been done to identify different classes of slopes, their vulnerability to instability and Kinematic analysis by Markland's Method, as the said method is applied to decipher the possible mode of failure and directions in the study area. The said approach was preferred considering the heterogeneous rock mass and being anisotropic with infinitely variable strength parameters that are difficult to determine precisely.The study concludes with the assessment of rock mass conditions and further categorization into fair and poor categories. As the area is facing the recurrences of mass wasting and slope failures, it could broadly be classified into planar and wedge failure. An attempt has been made for the assessment of the rock mass leading to better alignment of highways, tunnels and to foresee any potential rock slope failure during excavation/construction.SMR study concludes that the area falls in partially stable to unstable class.

Key words: Kinematic Analysis, Markland's Test, SMR, Ganderbal, Jammu and Kashmir Himalaya.

सारांश: पहाडी क्षेत्रों में पहाडियों के ढाल की स्थिरता कई परियोजनाओं जैसे भवन, पुल, जलविद्युत परियोजना, राजमार्ग, रेल–लाइन, नहरों तथा सुरंगों के निर्माण में चिंता का विषय होता है। प्रस्तुत शोध पत्र में ढालों की स्थिरता का अध्ययन प्रेंग तथा गंदेरबल के मध्य किया गया है, जो कि जम्मू एवं कश्मीर राज्य के गंदेरबल जिले के अंतर्गत आता है। गंदेरबल जल–विद्युत परियोजना सिंद नदी के बांये तट पर स्थित है। सिंद नदी झेलम नदी की सहायक नदियों में से एक है। ढालों की स्थिरता का मूल्यांकन ढालों के विभिन्न वर्गों की पहचान के लिए, ढालों की संवेदनशीलता एवं अस्थिरता का आकलन मार्कलैण्ड विधि द्वारा प्रगतिकी विश्लेषण के माध्यम से किया गया है। क्योंकि यह विधि ढालों के सरकने या क्षरण होने की दिशा तथा संभावित प्रकार का आकलन करने के लिए उपयुक्त है। उक्त विधि को इसलिए भी वरीयता दी गयी है क्योंकि अध्ययन क्षेत्र में विजातीय शैलो की अधिकता है जिसके कारण असमदैशिक एवं असंख्य परिवर्तनशील कारकों तथा मजबूती की स्थिति को विशुद्ध रूप से ज्ञात करना कठिन है। इस अध्ययन से यह निष्कर्ष निकाला गया है कि शैलों की स्थिति का आकलन उन्हें पुनः विभाजित करके सुदृढ़ एवं कमजोर क्षेत्र को बार–बार बृहत क्षरण एवं ढालों के गिरने/सरकने का सामना करना पड़ता है। ऐसी स्थिति में मोटे तौर पर शैलों के टूटने को फानाकार एवं तलीय टूटन में विभाजित किया गया है। प्रस्तुत अध्ययन में शैलों के लक्षणों के आंकलन के आधार पर प्रमुख रूप से राजमार्गों तथा सुरंगों के निर्माण के लिए उपयुक्त रेखन का प्रयास किया गया है, तथा खुदाई एवं निमार्ण कार्य के समय अनुमानित एवं संभावित शैल टूटन का आकलन किया गया है। उक्त विधि से ढालों की स्थिरता के मूल्यांकन के पश्चात् यह निष्कर्ष निकलता है कि उक्त क्षेत्र आंशिक रूप से स्थिर व आंशिक रूप से अस्थिर श्रेणी में आता है।

सूचक शब्द: प्रगतिकी विश्लेषण, मार्कलैण्ड विधि, ढालों की स्थिरता का मूल्यांकन, गंदेरबल, जम्मू एवं कश्मीर हिमालय।

NTRODUCTION

he Himalaya being the youngest mountain chain of the world s tectonically and climatically sensitive (Poonam *et al.* 2017, undriyal *et al.* 2015). Problems of slope failure are very ommon in the Himalayan region. Every year the region faces everal landslides, which create risk to human lives and nfrastructures such as highways and civil structures like ams, buildings etc. Landslide is defined as the movement of a nass of rock, debris or earth down a slope (Cruden 1991), can e triggered by a variety of external stimuli, such as heavy ainfall, intense earthquake, water level change, and rapid tream erosion that cause a rapid increase in shear stress or ecrease in shear strength of slope- forming materials Asthana & Sah 2007; Bhambri *et al.* 2017; Chaudhary *et al.* 010).

The state of Jammu & Kashmir is strategically very ensitive and distinct with respect to topography and climate, ost part of the state is mountainous; the topography along with the climatic condition and various anthropogenic interventions have made it susceptible to natural hazards. Landslides are one of the natural hazards that are common and peculiar to the state. Almost every year the state faces the problem of landslides which affect society in many ways like loss of lives, damage to houses, agricultural land and other infrastructures like roads and dam sites. The vulnerability has increased because of presence of unstable and fragile lithology, seismicity and various unscientific developmental activities. Deforestation, unscientific construction, terracing, encroachment on steep hill slopes are a few and foremost anthropogenic activities which have increased the frequency and intensity of landslides.

The study area comes around a proposed New Ganderbal Hydro Electric Project in Ganderbal district (Fig. 1A). It is a run-off the river scheme located on the left bank of Sind river. Besides power generation, the project envisages providing drinking water facilities and irrigation to the local command

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Water quality assessment of the reservoirs of Lambagad and Srinagar in relation to suitability for uses, Alaknanda Valley, Garhwal Himalayas, Uttarakhand, India

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Abstract

Reservoirs are the anthropogenic features that accumulate a large volume of water behind them and in turn alter the physico-chemical and biological characteristics of water. The Alaknanda river is a major source of drinking water in the study area. Present study outlines the anomalies in the water in two reservoirs of Lambagad and Srinagar. The two reservoirs were selected and their physico-chemical and biological characteristics measured in laboratory and in field. The data obtained was merged into a single number i.e. water quality index. With this index the upstream and downstream effects on the water quality was calculated in the form of anomaly. It was observed that WQI in the downstream of reservoir has improved as compared to the upstream. WQI in the downstream of reservoir at Lambagad in pre and post monsoon was 140.462 and 87.76 respectively as compared to 258.421 and 215.1 in the upstream of the reservoir. WQI in the downstream of reservoir at Srinagar in pre and post monsoon was found to be 67.3416 and 57.8746 respectively as compared to 86.9244 and 64.66 in the upstream. Water quality Index in the Srinagar reservoir in pre and post monsoon seasons are123.193 and 96.0176 respectively. The study concludes that the downstream site of reservoirs has better water quality as compared to upstream.

Key words: Water quality index, water quality anomaly, weighted arithmetic index method.

Introduction

Rivers are one of the biggest source of potable water. With the advent of anthropogenic influences these water bodies are under severe environmental stress. The Alaknanda river originating from Satopanth glacier located in higher Himalaya passes through such anthropogenic zones and the water quality is deviated. Reservoirs are one such anthropogenic feature which convert the fluviatile form of the river into the partially lacustrine and hence are able to deviate from the physical, chemical and biological parameters associated with water of the river. This in turn causes a corresponding water

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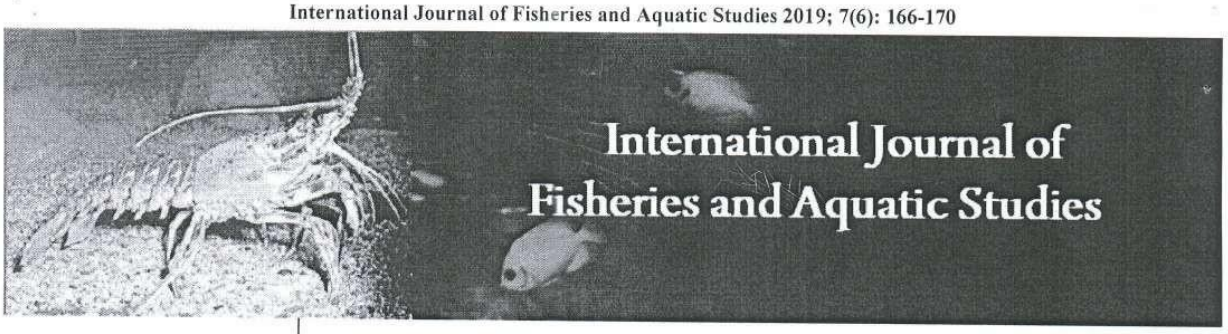

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Water quality assessment of Tehri dam reservoir in the context of its potential in aquaponics, Uttarakhand

Rawat AM, Bagri DS and Kumar S

Abstract
The State of Uttarakhand is one of the Himalayan States having more than 3/4th of its geographical area as mountainous. Agriculture is not of commercial nature in most of its parts except in the Terai ones. The geographical constraints are hampering the traditional form of agriculture here. The reservoir of Tehri dam, having area nearly 52 Km^2, offers an opportunity to switch over to the non-traditional practices in the sector like aquaponics and that too the commercially viable ones. This soil less media can be a potential site for the new and innovative farming practices. In the study area, the water quality of the reservoir is assessed by the authors and observed that the parameters like pH, dissolved oxygen, temperature and nitrates, are quite suited to the Aquaponics with a variety of plants. Sampling has been done in Dobra Chanti, Koti, and Pipaldali all coming under lake area at various parts. The pH, DO, Temperature, Nitrate at Dobra Chanti is 9.2,8.5 ppm, 24.9 degrees, 2.3 respectively. The values for Koti are 9.23, 9.1 ppm, 22.5 degrees, 3.5 ppm respectively and for Pipaldali are 9.17, 9.3 ppm, 23.3 degrees, and 0.4 ppm respectively.
As the comparative study of the above parameters was done by [1, 2, 7] it is found that the Tehri dam reservoir has a high potential for the said bio-integrated system. Thus, the given idea facilitates that the nutrient solution may lead to an increase in commercial agriculture, agro-business which will culminate in employment opportunities and further research and development in this field. Moreover, such practices may also be carried out in the reservoir and other impounded lakes in the state.

Keywords: Water quality, reservoirs, mountains, aquaponics, sustainable agriculture, business model

1. Introduction
Aquaponics is a very innovative form of agriculture which makes a kind of ecosystem between the fish and certain plants that can grow in water. This is totally a soil less form of agriculture. Here the nutrient for the plant growth is provided by the excretory products of fish which are broken down by microorganisms so that the resultant by-product can be used [7]. This method allows a sustainable growth to the crop without using the fertilizers and chemicals as the harmless nutrients acts as a Natural fertilizers and ensure the growth of plants [1, 24]. It allows us to save maximum water that could be lost in the conventional mode of farming through percolation into the land. The Himalayan terrain is very rugged and at the same time, the water and land resources for the crop production are too limited to be viable for commercial production. At such terrains we need a very different form of agriculture that could generate more output as compared to the conventional mode. Aquaponics is one such method that is capable of producing up to three to six times the quantity of plants output of a conventional planting system [22], and utilize less amount of freshwater needed to produce fish in a conventional aquaculture system [15]. So this system is perceived to be a possible sustainable solution to the inadequacies of fish and crop production as well as unemployment and trade deficit (due to high importation of food products) in many underdeveloped and developing countries [7]. From an environmental perspective, aquaponics stands out as a resource efficient system of food production that minimizes the externalities and allows cascading of nutrients that otherwise would cause eutrophication problem in the surrounding [2, 16, 17].
We intend to develop a new model of aquaponics in mountain agriculture by utilizing the huge area of Tehri dam reservoir as an aquaponics media. Tehri dam has been a source of employment for the locals in the last couple of years. The fish production in the reservoir is at a very large scale. The idea of changing the aquaculture into aquaponics is the basic theme of the present study.

COMPARATIVE EVALUATION OF DIGITAL ELEVATION MODEL BASED ON ELEVATION DATA AND TERRAIN ATTRIBUTES LEADING TO THEIR VALIDATION

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KEYWORDS: Elevation data, Accuracy, Error statistics, Terrain attributes.

ABSTRACT: Digital Elevation Model (DEM) is the 3D-representation of terrain surface in the discrete form and a standard tool to examine the hydrological and research application related to terrain characterization, landscape and water resources management. It helps in identifying physical features of an area, watershed delineation and stream network generation. However, several issues related to DEM's accuracy is the utmost concern for researchers. The present study is based on the comparative studies of DEMs viz., Cartosat-1, SRTM, ALOS and ASTER having the same spatial resolution of 30m each, under two different categories of elevation data and topographic attributes. The vertical accuracy of DEMs is examined by using ground control points as a reference level of elevation generated from topographic map. Analysing different sources of error in the DEMs, the RMSE and MAE based validation of elevation suggests that Cartosat-1 shows relatively high vertical accuracy (RMSE=45.2 & MAE=7.7) and ASTER shows the least (RMSE=60.5 & MAE=34.6). The grid size, spatial variation and vertical accuracy of DEM are among the prime attribute of data sources to determine the variation in basin morphometry. The study area shows a gradually undulating topography with 5th order drainage network. An inference can be made out of research study that the mean elevation values of ALOS, SRTM, Cartosat-1 are relatively lower than ASTER whereas differences in stream parameters are also observed. Mean bifurcation ratio value, which varies from 3.8-4.4, indicates that the area is structurally controlled.

1. Introduction:

Digital Elevation Model (DEM) is having the infinite sets of application in the areas of geomorphology, characterisation of watershed, ecology, surface runoff, modelling related to hydrology, soil erosion potential & agriculture etc. Significance of accurate DEM is mandatory

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Trend Analysis of Annual and Seasonal Time Series over the Last 46 Years in Asan Watershed, Doon Valley Based on Gridded Data Set

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ABSTRACT

The study is carried out with changing long-term trend and variation in one of the significant climatic element. The daily gridded rainfall data of spatial resolution 0.25°x 0.25°, for the last 46 years *i.e.* 1970-2015, has been processed for the Asan watershed located in Doon Valley, Uttarakhand. The non-parametric Mann-Kendall (MK) test together with Sen's Slope Estimator has been used for the determination of trend and slope magnitude in the watershed respectively. The gridded statistics of annual and seasonal precipitation trends have been studied here to achieve the objective. It has been observed that the magnitude of precipitation in annual and monsoonal time series are increased for all grids except for grid 6 and 8 which show a decreasing trend. The Post Monsoon time series shows a decreasing trend in all grids except for grid 6 which show positive whereas both the summer and winter rainfall show increasing trend except for grid 6. The Coefficient of variability shows variation for annual and seasonal rainfall suggesting overall insignificant changes in the area.

Keywords: Statistical trend analysis, Mann-Kendall test, Sen's slope estimator, Rainfall variability, Watershed

INTRODUCTION

Food production, conservation and management of water resources are a prime and significant concern of any development and planning. Change in climatic conditions with time is responsible for the loss of freshwater availability. IPCC (2007), revealed that in the mid of 21st century, 10-30% of the water present in the earth will project up and also fall in annual average rainfall. Precipitation is important for the nourishment of vegetation and agriculture. Particularly in developing countries, the adverse effect of change in climate on small farmers is emphasized, as they are mostly dependent on natural and traditional methods of cultivating crops (UNDP, 2014). Also, it plays an important role in shaping hydrology and water quality. Rainfall together with temperature affects the variability of weather to a large extent to determine the crop cultivation in a different region of the world.

Climate change with reference to rainfall variability also discussed by various researchers *viz.*, Asfaw *et al.* (2018), Pandey *et al.* (2001), Gajbhiye *et al.* (2015; 2016), Longobardi *et al.* (2009), Hamilton *et al.* (2001), Birsan *et al.* (2005), Jhajharia *et al.* (2009, 2012, 2014 a, b), Kumar *et al.* (2010), Krishan *et al.* (2016; 2018), Xu *et al.* (2007), Modarres *et al.* (2007).

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Sedimentary thickness of the northern Indo-Gangetic plain inferred from magnetotelluric studies

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Knowledge of the sedimentary thickness and configuration of the basement structure are important to estimate the seismic hazards in active foreland basin. We present sedimentary thickness of the northern Indo-Gangetic plain estimated from impedance tensors of 12 magnetotelluric sites. Occam's one dimensional inversion scheme was applied to invariant of the magnetotelluric tensors for the period range of 0.001–1 sec at each site. Inverted one dimensional model corroborates north-easterly dipping Indian basement and accordingly increased thickness of the sedimentary column towards north and east direction. The top sedimentary layers of varying thickness and resistivity are correlated with the known borewell logs and previous geophysical studies around the study area. Significant difference is observed in the resistivity of the Indian basement and thickness of the sedimentary column across the Delhi Hardwar Ridge. The difference in resistivity may be an indicative of variation in compactness and degree of saturation of the sedimentary cover and the nature of the Indian basement rock across the Delhi Haridwar Ridge.

Keywords. Indo-Gangetic plain; Himalaya; resistivity; magnetotelluric; 1D inversion; dimensionality.

1. Introduction

The sediments of the Indo-Gangetic plain (IGP) have varying thickness of ~1–6 km (Lyon-Caen and Molnar 1985; Borah *et al.* 2015). These sediments have been deposited over a deep trough formed by solid rocks of the Indian crust (Sastri *et al.* 1971; Rao 1973; Singh 1996). Geology and tectonic setting of the IGP, is closely related to the formation of the Himalayan orogeny. Neo-tectonically active IGP was formed in response of the Himalayan uplift after the collision of India and Eurasia continental plates (Dewey and Bird 1970; Pati *et al.* 2015). Due to the collision and subsequent thrusting, the old sedimentary prism of an intermediate sea was folded, faulted, thrusted and uplifted along with its basement in Cenozoic period (Burbank *et al.* 1996; Najman *et al.* 2004). From north to south, these fault lines are named as Indo-Tsangpo suture zone (ITSZ), South Tibetan Detachment (STD), Main Central Thrust (MCT), Main Boundary Thrust (MBT), Himalayan Frontal Thrust (HFT) (Gansser 1964; Ni and Barazangi 1984; Yin 2006; Jain *et al.* 2016; Thakur *et al.* 2018). Further south of the HFT, a flexure was developed on the Indian plate due to collision and partial subduction below the overriding Eurasian plate. Later, the debris of the Himalayan sediments brought by the major perennial rivers namely, Indus, Ganga, and Brahmaputra along with their

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RESERVOIR EFFECTS IN THE DISSOLVED OXYGEN OF ALAKNANDA RIVER, GARHWAL, HIMALAYA, UTTARAKHAND, INDIA

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ABSTRACT

Dissolved Oxygen is one of the most crucial component that determines the holiness of any water body. Rivers has been the lifeline for many civilizations they pass by, and the present scenario too shows the huge dependency of humans in the rivers for one or many reasons. These dependencies in the rivers has huge impact in the quality of rivers and their health. Creation of manmade reservoirs for the power generation in the Himalayan Rivers, has been a common trend. The reservoirs convert the riverine form of the water to the lacustrine one. In the present study the impact of man-made reservoir in the dissolved oxygen of the river has been worked out in pre and post monsoon seasons. The dissolved oxygen within the reservoirs has depleted compared to the upstream and the downstream of reservoir in both the seasons. The DO within the reservoir in pre-post monsoon seasons is 5.1 & 4.55 respectively, which is low compared to the upstream values of 5.53 and 5.85 respectively in the said seasons. The downstream DO values also shows the better conditions of 6.5 and 7.15 respectively. Thus, the study suggests that the Srinagar reservoir has the capability to deviate the nature of the flowing water.

Keywords:

Dissolved oxygen; Himalayan River; Water Quality; Reservoirs.

1. Introduction

Dams are physical barriers in river systems, and they and their associated impoundment water can result in changes to the natural flow regime, which in turn may change the physico-chemical parameters associated with the water Palmer et al. (1990). Ward & Stanford (1983) suggests that the dams and their reservoirs has the ability to shift the parameters longitudinally upstream or downstream. Similar to wetlands and larger reservoirs, small reservoirs temporarily store storm-water that is gradually released, thus delaying and mitigating peak flows (Larm, 2000; Guo, 2001; Ravazzani et al., 2014).Dissolved oxygen being a very sensitive aspect of a river can vary within the reservoir depending on whether reservoir releases occur from the surface or near the bottom of the water column (Willey et al., 1996; Neumann et al., 2006). This study focuses on the effects of a small reservoir in the dissolved oxygen of pristine river of Himalaya viz. Alaknanda and how the conversion of the free flowing river water to a different continuum i.e, reservoir makes the river to behave in a very different manner that is manifested in its parameters.

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REVIEW PAPER

Analysis of tectonic deformation on channel morphology through quantitative geomorphic indices and DEM derived drainage system

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Abstract

Drainage basin dynamics of any river is controlled by geomorphic attributes which include both surface and subsurface characteristics of a watershed. These characteristics comprise erosional and deformational processes affecting the hydrological and morphological conditions of the watershed. Similarly, the tectonic setup of the watershed influences the terrain topography and geomorphology as well. The paper deals with the evaluation of DEM-derived parameters related to morphometry and tectonic setup in the Asan watershed, Doon Valley, Uttarakhand. The assessment of active tectonics in the study area is based on the parameters related to the morphometry and morphotectonic characters of the watershed. These terrain attributes are determined using Cartosat-1 DEM (10 m) using GIS to investigate the structural setting. The parametric evaluation concerning morphometric analysis helps to understand their significance in watershed prioritization and management while the tectonic analysis helps to determine the structural setup and identifying the hazard-prone area, if persists, in the watershed. The study area falls downhill of tectonically active Lesser Himalaya and Siwaliks, make it an ideal location to determine the degree of relative tectonic activity in the area. The average of measured attributes is used to evaluate the combined classification of the Relative Active Tectonic Index (R_i). The outcome reveals that the watershed is tectonically active that experienced a differential rate of tectonism and have a consistence relationship between structural disturbances and basin geometry.

Keywords Morphometry · Geomorphic indices · Watershed · DEM · GIS · Relative active tectonic index

Introduction

The active Himalayan mountain chain is subjected to various deformational processes because of tectonic uplift, weathering and denudational processes (Valdiya 2003; Perez-Pena et al. 2010). The geomorphological setup of a particular watershed is strongly affected by the deformational processes occurring within them. It is strongly dependent upon the tectonic activities occurring into it, which influences the drainage system, terrain topography and landscape development. Tectonic geomorphology describes the formation of geomorphic features which is the results of the relationship between the tectonic and surficial processes (Burbank and Anderson 2001). In controlling river behaviour and the development of drainage network, tectonism plays a significant part (Holbrook and Schumm 1999; Sinha-Roy 2001; Valdiya and Narayana 2007). This can be described both qualitatively and quantitatively (Hare and Gardner 1985; Keller and Pinter 2002). The drainage network in active regions is susceptible to tectonic features viz., faults, folding and tilting. River and streams are the significant landforms that are very sensitive to tectonic movement as these affected by incision, diversion and asymmetry in a tectonic environment (Cox 1994). Watersheds behave as the fundamental unit of the fluvial landforms and act as an ideal entity to understand the tectonic activity in the area (Strahler 1964). Geomorphological quantitative studies of the basin relate with the study of morphometric and morphotectonic attributes of tectonic geomorphology. The geomorphic feature gives quantitative information about the tectonic processes

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Hydrological Characteristics of 7th February 2021 Rishi Ganga Flood: Implication towards Understanding Flood Hazards in Higher Himalaya

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ABSTRACT

A flash flood that originated from Raunthi Gad-a tributary of the Rishi Ganga river, in Garhwal Himalaya, caused unprecedented loss to lives and damaged two hydropower projects on 7th Februray 2021. In order to asses the flood magnitude, the flow parameters of the flood were calculated using the super-elevation of the flood marks preserved in the flood affected valleys.

The textural characteristics of the flood deposits in the upper reaches of the valleys indicate dominance of debris flows. The peak discharge upstream of the confluence of Rishi Ganga and Dhauli Ganga was around 1.1×10^5 m^3/s, which was four order of magnitiude higher than the normal peak discharge (~ 3 m^3/s). The flow achieved a velocity of 30±3 m/s. An exponential reduction in the flow velocity (from ~37 to 2 m/s) with distance is observed. For which the river gradient and increase in sediment load is implied flow that along its entrained way downstream between Raini and Tapovan. Considering the sensitivity of paraglacial zones to climate change, the paper calls for detailed studies pertaining to the response of paraglacial zones to extreme weather events. Importnatly, it is necessary to have more hydrological data covering multiple valleys for predictive model simulation of the nature and magnitude of such disasters in future.

INTRODUCTION

India stands among the six most flood-affected countries in the world (Luo et al., 2015). Floods in Himalaya are generally produced by extreme precipitation events (e.g. Sah et al., 2003; 2010; Juyal, 2010; Rana et al., 2012), landslide lake outburst floods (LLOFs) (Wasson et al., 2013; Rana et al., 2013), and the glacier lake outburst floods (GLOFs) (Korup et al., 2006) or due to the meteorological disturbances (Srivastava et al., 2017; Kale, 2004; Ziegler et al., 2014) or the combination of the above factors. The June 2013 Kedarnath flash-flood was triggered by a combination of high rainfall, snowmelt and subsequent Chorabari lake outburst (Sati and Gahalaut, 2013; Rana et al., 2013; Doval et al., 2013). It has been observed that debris flow triggered by high intensity rainfall events from paraglacier zones are one of the major factors responsible for devastating the infrastructures in the Higher Himalaya (Sundriyal et al., 2015).

The upper Alaknanda river catchment is dominated by the glacial and paraglacial processes in which the Rishi Ganga, a tributary of Dhauli Ganga, contains the largest concentrations of glaciers. (Fig. 1). On 7th February 2021, at around 10:30 a.m. a debris laden flash flood originated from Raunthi Gad -a tributary of Rishi Ganga. The flood water devastated a 13.2 MW hydropower project at Raini village taking at least 80 lives. Further downstream, in the Dhauli Ganga valley, it destroyed an under-construction barrage of 520 MW hydropower project and killed nearly 150 people (either swept away or buried/trapped in the tunnel).

From future risk assessment point of view, this flood raised two important questions: (i) what was the process responsible for the genesis of the debris-laden flash flood from a small stream? (ii) What determined the pattern of damage in the valley? To address these questions, hydrological parameters are employed for determining the magnitude and characteristic of this flood as it moved down valley. The geomorphic imprints left behind by the flood are documented by using the total station to reconstruct pre- and post-flood scenarios with respet to channel geometry. Further, the hydrological characterization of the flood was done using empirical methods (for calculating flood velocity and discharge).

STUDY AREA

The Rishi Ganga catchment (area ~690 km^2) is located in the Garhwal region of Central Himalaya, India (Fig.1). The Rishi Ganga river, a sub-tributary of the Alaknanda river, emanates from the group of glaciers in the Nanda Devi Biosphere Reserve (NDBR) and joins Dhauli Ganga river near Raini village. The elevation in the catchment ranges from ~1930 m above mean sea level (a.m.s.l.) at the confluence to 7817 m a.m.s.l (Nanda Devi). The glaciers cover ~25 % of the total area of this basin. It hosts seven major valley glaciers of varying length ranging from 5 to 10 km (Kumar et al., 2020) including a few hanging glaciers and cirques (Fig.1). According to glacier inventory (RGI Consortium, 2017), ~74 glaciers having areas from 0.02 km^2 to 33.5 km^2(with an average area of 2.3 km^2) are located in this basin. Among these eight large glaciers (area>5 km^2) cover 72% of total glaciated area. The major concentration of the glaciers feed the east-west flowing stream, while the Raunthi (Bank) glaciers contribute to the northward-flowing Raunthi Gad (Gad - stream).

The Rishi Ganga valley is characterized by recent glacial deposits in the form of moraines. Apart from the moraines, significant amount of debris is available in the form of scree cones emerging from the cirques and slope failures (Fig.1). The channel gradient is steep (10^{-1}), to moderate (10^{-2}) and the average hill slopes ranges from

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Relationship of isotopic variations with spring density in the structurally controlled springs and related geosystem services in Alaknanda Valley, Garhwal Himalaya, India

Aakash Mohan Rawat[1]✉, Dhirendra Singh Bagri[1], Sudhir Kumar[2], Ruchi Badola[3] & Syed Ainul Hussain[3]

As a traditional water source, springs are vital for Himalayan communities and it is essential to consciously focus on springs conservation. We report oxygen isotopes ($\delta^{18}O$) of spring water before, within, and after the tectonically active zones of the Alaknanda Valley, Uttarakhand. Higher variation of $\delta^{18}O$ in the spring waters is found in highly tectonically disturbed zone i.e., Zone-2 with $\delta^{18}O$ range − 4.9‰ to − 9.0‰ compared to tectonically less disturbed zones: Zone-1 and Zone-3 with $\delta^{18}O$ value range − 7.9‰ to − 9.9‰ and − 7.4 to − 10.2‰ respectively. We hypothesize that the highly active thrust zones (Zone-2) with increased permeability compared to other Zones, manifested as greater spring density, results in higher water recharge in Zone-2. Very high to high spring density stretches are dominant in Zone-2 compared to Zone-1 and Zone-3. Stretches in Zone-2 with high spring density formed due to its highly tectonically active nature leads to the higher isotopic variation in Zone-2. The study also identifies the geosystem services provided by thrust zones as water resources to the local people and need of conservation modalities to manage the spring water resources in the thrust zones.

Many accounts associated with the earthquake-induced permeability enhancements and subsequent release of the new water sources have been documented worldwide[1–3]. Further, the coseismic hydrological changes propose the groundwater mixing among different aquifers through new cracks[4], which is the manifestation of the enhanced permeability due to the earthquakes. Stable isotopes of water have been used as proxy[5] to show that that earthquake enhanced permeability and release water from mountains as a subsurface hydrogeological response to the 2016 Mw 7.0 Kumamoto earthquake. The stable isotopic variations have been used as a direct fingerprinting tool to examine the changes in between before and after earthquakes[2,3,6]. On the other hand, the variation in the isotopic ratios ($^{18}O/^{16}O$) of oxygen has generally been attributed to evaporation of meteoric water[7], together with ^{18}O-shift by the water–rock interaction[8] and changes of the oxygen isotopes before earthquakes[9–11]. Also, the isotopic variation with altitude has been worked out by[12,13]. This progressive depletion of the heavier isotope in rain with altitude, as the cloud ascends, is often referred to as the "altitude effect". Thus, most of the studies are focused either on the earthquake or altitude-regulated isotopic variations (altitude effect) or due to the other fractionation processes. Other factors like the very high abundance of springs sources or very high spring density in some stretches and the presence of active thrust zones may also also bring changes in the stable water isotopes giving the indication of water recharge in the zone. As the stable isotopes of oxygen indicate the recharge sources of the water[14–16], the present work has been carried out to understand the impact of tectonics on isotopic composition of spring water.

In the present work, we tried to decipher the first account of the thrust-controlled stable oxygen isotope variation in the spring waters of Alaknanda valley located in Garhwal Himalayas, Uttarakhand, India.

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Identifying potential hotspots of land use/land cover change in the last 3 decades, Uttarakhand, NW Himalaya

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ABSTRACT

Uttarakhand region in the NW Himalaya has experienced two extreme climatic-geomorphic events within last 10 years that killed more than 6000 people. Though these events, like many others in the Himalaya, have been attributed to climate-change and anthropogenic disturbances, identification of potential hotspots of land use/land cover change is rarely attempted to make future inferences for disaster risk reduction. An evaluation of spatio-temporal changes in land use/land cover can be used to identify such hotspots. Therefore, we analysed the spatio-temporal changes in a climatically sensitive and natural disaster-prone area (~28856 km^2) of Uttarakhand (NW Himalaya), India, by comparing the satellite data of years 1991-2020 for ten land use/land cover elements to track the spatio-temporal changes over these years. Results revealed the formation of two hotspots exhibiting relatively more changes in land use/land cover pattern. Though the anthropogenic influence is observed in both hotspots, the influence of spatio-temporally changing climatic parametres is also noted. In view of frequent extreme climatic-geomorphic events, temporally increasing population and tourist pressure, and temporally changing climatic conditions, it is vital to identify hotspots having dominant changes in land use/land cover to understand the possible source of potential disasters.

Keywords: Land use/Land cover; Uttarakhand; Himalaya; Climate; Anthropogenic action.

1.0 INTRODUCTION

The present pattern of infrastructural development and subsequent population increase in the fragile ecosystem in mountain ranges have resulted in increased stress on environment in the form of land use/land cover changes (Paudel et al. 2016). The studies pertaining to the land use/land cover refer to extracting the information about physical characteristics of the earth surface features along with the patterns of their utilization in time and space (Rawat & Kumar, 2015). Change in the land use/land cover is the primary variable that affects a wide

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Nature and composition of interbedded marine basaltic pumice in the ~52–50 Ma Vastan lignite sequence, western India: Implication for Early Eocene MORB volcanism offshore Arabian Sea

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The recognition of pyroclasts preserved in sedimentary environments far from its source is uncommon. We here describe occurrences of several centimetres-thick discontinuous basaltic pumice lenses occurring within the Early Eocene Vastan lignite mine sedimentary sequence, western India at two different levels – one at ~5 m and the other at 10 m above a biostratigraphically constrained 52 Ma old marker level post-dating the Deccan Volcanism. These sections have received global attention as they record mammalian and plant radiations. We infer the repetitive occurrence of pumice have been sourced from a ~52–50 Ma MORB related to sea-floor spreading in the western Arabian Sea, most plausibly along the Carlsberg Ridge. Pyroclasts have skeletal plagioclase with horsetail morphologies ± pyroxene ± Fe–Ti oxide euhedral crystals, and typically comprise of circular polymodal (radii ≤10 to ≥30 μm), non-coalescing microvesicles (>40–60%). The pumice have undergone considerable syngenetic alteration during oceanic transport and post-burial digenesis, and are a composite mixture of Fe–Mn-rich clay and hydrated altered basaltic glass (palagonite). The Fe–Mn-rich clay is extremely low in SiO_2, Al_2O_3, TiO_2, MgO, alkalies and REE, but very high in Fe_2O_3, MnO, P, Ba, Sr contents, and palagonitization involved significant loss of SiO_2, Al_2O_3, MgO and variable gain in Fe_2O_3, TiO_2, Ni, V, Zr, Zn and REE. Bubble initiation to growth in the ascending basaltic magma (liquidus ~1200–1250°C) may have occured in ~3 hr. Short-distance transport, non-connected vesicles, deposition in inner shelf to more confined lagoonal condition in the Early Eocene and quick burial helped preservation of the pumice in Vastan. Early Eocene Arabian Sea volcanism thus might have been an additional source to marginal sediments along the passive margin of western India.

1. Introduction

The record of millimetre to centimetre-sized small pyroclastic detritus, preserved in sedimentary environments far from its source is largely unrecognized in the geologic record (e.g., Carey *et al.* 2001; Risso *et al.* 2002). Wadia (1944) was one of the first to identify abundant pumice fragments in coastal Sri Lanka, an island where no inland volcanic eruptions have occurred. Records of submarine volcanism

Keywords. Pumice; basalt; sea rafting; Eocene; Carlsberg Ridge; Vastan lignite mine; India.

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ARTICLE

A GYMNODONT FISH JAW WITH REMARKABLE MOLARIFORM TEETH FROM THE EARLY EOCENE OF GUJARAT, INDIA (TELEOSTEI, TETRAODONTIFORMES)

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ABSTRACT—The lower jaw of a gymnodont fish collected from the lower Eocene Cambay Shale Formation in Gujarat Province, western India, has fused dentaries without a beak and a remarkable series of teeth that are unique among all known fossil and living Tetraodontiformes. The teeth are molariform, with raised spokes radiating inward from the emarginated peripheral edge of the crown. Tooth development is intraosseous, with new teeth developing in spongy bone before they erupt and attach to the dentary by pedicels. Although many of the 110 tooth loci in the fossil have lost their teeth, in life the teeth would have grown to fit tightly together to form a broad and continuous crushing surface. The estimated age of the Cambay Shale vertebrate fauna is ca. 54.5 Ma, making the jaw the second oldest confirmed gymnodont fossil. Preliminary comparisons with extant taxa of gymnodonts with fused dentaries (e.g., *Diodon, Chilomycterus*, and *Mola*) show detailed similarities in jaw structure, but further study of the dentition is needed to better understand the evolutionary position of the new fossil. We describe the new gymnodont as †*Avitoplectus molaris*, gen. et sp. nov., in †Avitoplectidae, fam. nov., and place the family as incertae sedis within Gymnodontes.

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INTRODUCTION

Excavations during 2015 at a channel deposit in the early Eocene (ca. 54.5 Ma) Tadkeshwar open-cast lignite mine in Gujarat Province, western India, yielded terrestrial mammals, lizards, snakes, frogs, and birds as well as assorted marine and brackish-water animals, including shark and ray teeth and echinoderm spines (Smith et al., 2016). Among these is the lower jaw of a gymnodont tetraodontiform fish, initially reported by Smith et al. (2016:976, fig. 7D, E), in which the dentaries are fully and indistinguishably fused across the midline, as in many other fossil and extant gymnodonts (i.e., triodontids, †*Zignoichthys*, †*Balkaria*, diodontids, and molids; see Tyler, 1980; Tyler and Santini, 2002; Bannikov et al., 2016; Close et al., 2016). The dentition of the fossil, however, differs from all other gymnodonts (and all other tetraodontiforms) in the remarkable structure of its teeth. It lacks a beak (as present in, e.g., †*Balkaria, Diodon*, and *Mola*), and the teeth are molariform. The occlusal surfaces of most teeth have enameloid spokes that radiate inward from the emarginated peripheral edge of the crown, forming a basin at the center of each tooth. The teeth are also distinct from those of most other actinopterygians. In those groups with superficially similar teeth (characins, such as *Alestes*, and †pycnodontids), the dentaries are not fused across the midline as they are in most gymnodont families.

There is a rich literature on fossil gymnodonts, the oldest of which is †*Balkaria histiopterygia* from the earliest Eocene of the north Caucasus of Russia (ca. 55.8 Ma; Bannikov et al., 2016). Almost as old is †*Ctenoplectus williamsi*, described from the middle early Eocene London Clay (ca. 53 Ma; Close et al., 2016). Most other early gymnodont fossils are from the late early Eocene (ca. 50 Ma) and are prominent in the ichthyofauna of Monte Bolca, Italy (Tyler and Santini, 2002). A diodontid jaw described by Gallo et al. (2009) was tentatively attributed to the Upper Cretaceous of Brazil, but it remains of questionable age (Dornburg et al., 2014; Bannikov et al., 2016). Bayesian total-evidence tip-dating suggests

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MEMOIR ARTICLE

ANATOMY, RELATIONSHIPS, AND PALEOBIOLOGY OF *CAMBAYTHERIUM* (MAMMALIA, PERISSODACTYLAMORPHA, ANTHRACOBUNIA) FROM THE LOWER EOCENE OF WESTERN INDIA

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ABSTRACT—The anatomy of *Cambaytherium*, a primitive, perissodactyl-like mammal from the lower Eocene Cambay Shale Formation of Gujarat, India, is described in detail on the basis of more than 350 specimens that represent almost the entire dentition and the skeleton. *Cambaytherium* combines plesiomorphic traits typical of archaic ungulates such as phenacodontids with derived traits characteristic of early perissodactyls. *Cambaytherium* was a subcursorial animal better adapted for running than phenacodontids but less specialized than early perissodactyls. The cheek teeth are bunodont with large upper molar conules, not lophodont as in early perissodactyls; like perissodactyls, however, the lower molars have twinned metaconids and m3 has an extended hypoconulid lobe. A steep wear gradient with heavy wear in the middle of the tooth row suggests an abrasive herbivorous diet. Three species of *Cambaytherium* are recognized: *C. thewissi* (~23 kg), *C. gracilis* (~10 kg), and *C. marinus* (~99 kg). Body masses were estimated from tooth size and long bone dimensions. Biostratigraphic and isotopic evidence indicates an age of ca. 54.5 Ma for the Cambay Shale vertebrate fauna, the oldest Cenozoic continental vertebrate assemblage from India, near or prior to the initial collision with Asia. Cambaytheriidae (also including *Nakusia* and *Perissobune*) and Anthracobunidae are sister taxa, constituting the clade Anthracobunia, which is sister to Perissodactyla. We unite them in a new higher taxon, Perissodactylamorpha. The antiquity and occurrence of *Cambaytherium*—the most primitive known perissodactylamorph—in India near or before its collision with Asia suggest that Perissodactyla evolved during the Paleocene on the Indian Plate or in peripheral areas of southern or southwestern Asia.

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INTRODUCTION

Cambaytherium is a medium-sized, bunodont, perissodactyl-like mammal from the lower Eocene Cambay Shale Formation of Gujarat, India. Initially based primarily on lower dentitions, the genus was described as a perissodactyl by Bajpai et al. (2005a), who remarked on its bunodonty. Soon after *Cambaytherium* was named, Rose et al. (2006) described *Indobune vastanensis*, based on bunodont upper teeth, and assigned it to the family Anthracobunidae, then considered to be stem tethytheres or basal proboscideans (Gheerbrant et al., 2005b). Additional specimens demonstrated that these two genera were synonymous, with *Cambaytherium* having priority. However, neither of these earlier reports recognized the phylogenetic and paleobiogeographic significance of *Cambaytherium*; and were it not for subsequent discoveries of most of the skeleton, the taxon might have been relegated to comparative obscurity as an endemic taxon of little relevance to placentals outside of India. The present study provides a detailed account of the dental and skeletal anatomy of *Cambaytherium* and demonstrates that it occupies a key phylogenetic position with respect to the origin and relationships of the order Perissodactyla. Its phylogenetic relationships in turn have significant paleobiogeographic implications for the origin of the order Perissodactyla and the early diversification of Euungulata.

Initial comparison of *Indobune* upper teeth with those of the supposed anthracobunid *Nakusia shahrigensis* from the lower Eocene Ghazij Formation of Pakistan (Ginsburg et al., 1999) indicated a close relationship and was part of the evidence cited to support allocation of *Indobune* to Anthracobunidae. In the 1980s and 1990s, anthracobunids—a group apparently confined

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RAPID COMMUNICATION

CHEMICAL EVIDENCE OF PRESERVED COLLAGEN IN 54-MILLION-YEAR-OLD FISH VERTEBRAE

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Abstract: Collagens are the most abundant proteins in the animal kingdom. They form the structural framework of connective tissues such as bones, tendons and skin, and play an important biomechanical role in supporting tissue functions. The preservation of collagen in deep time is a topic of intense debate. Here we provide indisputable evidence for the presence of collagen in early Eocene fish vertebrae using online pyrolysis comprehensive two dimensional gas chromatography time-of-flight mass spectrometry (py-GC×GC-TOFMS) and immunofluorescence analysis. The presence of cyclic dipeptides such as diketodipyrrole, 2,5-diketopiperazine of proline-proline and 2,5-diketopiperazine of proline-glycine along with other nitrogen-bearing molecules in the pyrolysis products of the studied fossils unequivocally demonstrate that collagen can withstand degradation and diagenetic alteration. Immunofluorescence study also confirms the presence of collagen-I in the fossilized fish vertebrae. Contrary to common opinion, the present findings suggest that the preservation of collagen in fossilized soft tissues is not rare. We propose that one of the essential factors controlling the preservation of collagen is the establishment of a suitable microenvironment within the fossil, inhibiting diagenetic alteration including microbial decay.

Key words: collagen, fish vertebrae, Eocene.

Collagens are the most abundant protein in the extracellular matrix and in connective tissue of vertebrates (Shoulders & Raines 2009). In vertebrates, collagens are found in skin, bones, cartilage, tendons and corneas (Wess 2005). This structural protein family provides tensile strength, torsional stiffness and prevents mechanical failure of tissues (Ferraro *et al.* 2017). The fossil record of soft tissues provides invaluable insights into their evolutionary biology (Lindgren *et al.* 2014). Animal soft tissues are characterized by nitrogen-bearing macromolecules which are labile and prone to diagenetic alterations (Briggs & Summons 2014; Parry *et al.* 2018). There are several biological and chemical factors that influence the exceptional preservation of soft tissues in deep time (Schweitzer 2011). The mechanisms of soft tissue preservation often include entombment in concretions of carbonate or amber, or rapid cementation just after deposition of organic remains (Schweitzer 2011; Melendez *et al.* 2013; Grice *et al.* 2019). Collagen has been detected in dinosaur bones of Cretaceous age (Schweitzer *et al.* 2005; Asara *et al.* 2007; Schroeter *et al.* 2017). However, these findings have been widely disputed (Pevzner *et al.* 2008; Manning *et al.* 2009; Buckley *et al.* 2017). The common perception is that collagen cannot survive diagenetic alteration (Service 2017; Saitta *et al.* 2018). Here we demonstrate unequivocally, using online pyrolysis-comprehensive two-dimensional gas chromatography coupled to time-of-flight mass spectrometry (py-GC×GC-TOFMS) and immunofluorescence analysis, that collagen is preserved in Early Eocene fish vertebrae.

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An orb-weaver spider (Araneae, Araneidae) from the early Eocene of India

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Abstract.—A new fossil spider is described from the early Eocene (Ypresian) Palana Formation (54 to 57 Ma) at the Gurha opencast lignite mine, near Bikaner, western Rajasthan, India. It is the first report of a nonamber fossil spider from India. The fossil is referred to the modern genus *Nephila* Leach, 1815, but with hesitation because, while its habitus is similar to that genus, it lacks the behavioral synapomorphies that distinguish the genus.

Introduction

The golden orb-weaver genus *Nephila* Leach, 1815 is renowned for its enormous orb webs constructed with distinctive gold-colored silk, for its extreme sexual size dimorphism (females are gigantic compared to the males), and for being a conspicuous inhabitant of tropical forests (Kuntner et al., 2013). Some two dozen species are recognized in the genus, together with several subspecies (World Spider Catalog, 2018). Golden orb weavers inhabit tropical and subtropical regions throughout the world, and the enormous, permanent webs of the females serve as microecosystems for a variety of kleptoparasites and other cohabitants (Vollrath, 1987; Tso and Severinghaus, 1998; Agnarsson, 2003, 2010; Harvey et al., 2007).

Nephila and related genera (presently including *Clitaetra* Simon, 1889, *Herennia* Thorell, 1877, *Nephilengys* Koch, 1872, and *Nephilingis* Kuntner in Kuntner et al., 2013) were placed in the family Araneidae Clerck, 1757 by Simon (1894), together with other orb weavers, and close to the tetragnathines (Kuntner et al., 2008). They remained in Araneidae until Levi (1986), with doubt, and then Coddington (1990) transferred the nephilines and tetragnathines into the family Tetragnathidae Menge, 1866. The nephiline genera were raised to family status (Nephilidae Simon, 1894) in the work of Kuntner (2006), where they remained (but closer to araneids than tetragnathids, e.g., Pan et al., 2004; Álvarez-Padilla and Hormiga, 2011; Su et al., 2011) until Dimitrov et al. (2017) returned these genera to the family Araneidae as subfamily Nephilinae, a result also supported by Wheeler et al. (2017).

Despite the large size of the females, most fossil nephilines described are males in amber, mainly because of the need of adult males to wander from their webs to seek out the sedentary females. The youngest fossil nepheline described is *Minutunguis silvestris* Wunderlich, 2011, a male in Quaternary Madagascan copal. Miocene Dominican amber contains five species of *Nephila*, all males, described by Wunderlich (1982, 1986), and Wunderlich (2004) described nine male nephilines from Eocene Baltic and Bitterfeld amber, which he referred to three new genera: *Eonephila* Wunderlich, 2004, *Luxurionephila* Wunderlich, 2004, and *Palaeonephila* Wunderlich, 2004. The only female nephiline known hitherto from the Cenozoic Era is *Nephila pennatipes* Scudder, 1885, from Eocene beds at Florissant, Colorado. This species most closely resembles the one described here in size and geological age. Mesozoic nephilines include the males *Cretaraneus vilaltae* Selden, 1990 from the Early Cretaceous of Spain, *Geratonephila burmanica* (Poinar in Poinar and Buckley, 2012) from mid-Cretaceous Burmese amber, *C. liaoningensis* Cheng, Meng, and Wang in Cheng et al., 2008 from the Early Cretaceous of China, and *C. martensnetoi* Mesquita, 1996 from the Early Cretaceous of Brazil. However, the age of *Geratonephila* was disputed by Wunderlich (2015), who synonymized the genus with *Nephila*. From his long experience of working with Burmese amber, during which time he had never seen a nephiline in the deposit, Wunderlich (2015) considered that *Geratonephila* was more likely from the Dominican Republic, of Miocene age, in which deposit the modern genus is quite common; he suggested it might belong to *Nephila tenuis* Wunderlich, 1986. Similarly, the two spiders from the Early Cretaceous of China and Brazil are most likely not nephilines but were placed in the genus *Cretaraneus* because of their Cretaceous age.

The only female Cretaceous nephilines known are several large, undescribed specimens from the Early Cretaceous Crato Formation of Brazil, one of which was figured by Dunlop and Penney (2012, fig. 93). A giant female spider from the mid-Jurassic Daohugou Fossil-Lagerstätte of China was originally described as *Nephila jurassica* Selden, Shih, and Ren, 2011. However, shortly after its description, a giant male was discovered in the same beds, which was considered to be conspecific with *N. jurassica*; the species was placed in the new genus *Mongolarachne* Selden, Shih, and Ren, 2013 and removed from Nephilinae. Kuntner et al. (2013) had already

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First two cockroaches from the early Eocene of western Rajasthan, India (Insecta: Blattodea)

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We describe the first two Blattodea from the early Eocene Palana Formation of the Gurha opencast lignite mine, western Rajasthan, India. Although it is not possible to attribute them to a precise family, these large wings suggest a warm and humid paleoclimate for the area at that time.

Key words: Insecta, Dictyoptera, wings, Paleogene, paleoclimate, India

Dictyoptera are rather frequent in the fossil record since the late Carboniferous, they are mainly known from Europe, North and South America, and Northern and South-Eastern Asia (Siberia, China, Myanmar). They are clearly less frequent from the sub-continent of India, with few Permian and Mesozoic fossils (Fletcher, 1920; Rao & Shah, 1959; Verma, 1967; Dutt, 1977; Srivastava, 1988; Pinto *et al*., 1992; Kapoor *et al*., 1993; Engel & Pérez-de La Fuente, 2012; Arya *et al*., 2005). Indeed, fossil insects are rarely recorded from India, even if it since a long time ago (Hislop & Hunter, 1855; Hislop, 1860); but with the recent exception of those from the early Eocene Cambay amber (see Rust *et al*., 2010).

Here we describe the first two cockroach's wings from the early Eocene Palana Formation of the Gurha opencast lignite mine, western Rajasthan, India. Shukla *et al*. (2014) already indicated the presence of insects from this mine. Patel *et al*. (2019a) recently described an orb-weaver spider (Araneae, Araneidae) and reported only insects like *Formica* sp., mayfly naiad, etc. (Patel *et al*., 2019b) from the same formation, otherwise known for their fossil pollen, leaves, flowers, fruits (Shukla *et al*., 2014; 2018; Shukla & Mehrotra, 2019).

The sample site, also known as Gurha opencast lignite mine (72.52269°E, 27.5229°N), is located at 70 km from Bikaner (Fig. 1a). For the general geology of the subsurface Gurha lignite opencast mine, see Fig. 1b. The site is comprised of multiple layers starting from the pebbly ash bed in the basement, followed by the Palana Formation. It consists of various layers with variable thicknesses, including the base of lignite (4.5 m). A (3.8 m) carbonaceous shale intercalated with a thin band of dirty maroon sandstone (12.0 cm), variegated clay (6.0 m), carbonaceous shale, (3.7 m), variegated shale (3.5 m), and maroon shale (3.0 m), respectively. The Palana Formation is overlaid by the Kolayat Formation, which consists of variegated clays or fuller's earth (9.5 m), also overlaid by yellow ferruginous sandstones with lenses of clay and sandy shales (5.5 m), gritty sandstones, lime kankar (7.5 m) of the Jogira Formation, with recent alluvium and soil at the top (3.88 m).

The sedimentological and paleontological data, with plant leaves, rare fishes, and invertebrates, support a fluvio-lacustrine environment with the influence of volcanism at the base for the Palana Formation. The pollen assemblages indicate an early Eocene (Ypresian) age (Shukla *et al*., 2014).

The specimens were recovered by hand picking from the thin, laminated, carbonaceous, and maroon shale beds of the Palana Formation exposed in the Gurha opencast lignite mine Bikaner District, Rajasthan, India. They were studied using a Leica MZ-6 microscope. Photographs were taken using a Nikon D5500 DSLR camera and Olympus digital micropad 777 microscope. Specimens were at times treated with ethanol (95 %) on the surface to create greater contrast between the fossil and the surrounding matrix. The venation patterns were determined from composite line drawings of the part and counterpart, improved by using Corel draw X7 software. We follow the wing venation terminology of Snodgrass (1935) and Schubnel *et al*. (2020).

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Research papers

First fossil record of mulberry from Asia

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ABSTRACT

Although Asia shows moderate species richness of mulberry (*Morus* L.) today, unfortunately no mulberry fossil has been reported from the Cenozoic sediments of this continent to date. Here, we report for the first time the occurrence of leaf remains (both impression and compression) having similarity with modern leaves of *Morus* from the early Eocene sedimentary sequences of the Gurha opencast lignite Mine, western Rajasthan, India. The fossil specimens characterized by a heart-shaped ovate lamina, cordate base, long petiole, crenate–serrate margin, actinodromous nature of primary veins and craspedodromous type of secondary venation pattern are recognized as *Morus asiatica* Patel, Rana and Khan sp. nov. This record suggests that mulberry was an important component of tropical–subtropical evergreen forests growing in a warm humid climate in the area of north-western India during the Eocene. This taxon subsequently declined from the local present-day dry and desertic vegetation probably because of the drastic climate and latitudinal change in the area, related to the Himalayan Orogeny and rainfall seasonality since the Eocene.

1. Introduction

The mulberry, a group of angiosperms allied to Moraceae comprising of 40 genera and 1400 species, are cosmopolitan in distribution with the majority of species occurring in the Old-World tropics, particularly Asia and the Indo-Pacific Islands (Watson and Dallwitz, 1992; Rohwer and Berg, 1993; Berg, 2001; Berg, 2005a, 2005b). The family Moraceae is currently placed under order Rosales with six tribes namely, Artocarpeae, Moreae, Maclureae, Dorstenieae, Castilleae and Ficeae (Ribeiro, 2007; Clement and Weiblen, 2009; Chase et al., 2016; Milliken et al., 2009 onwards) and the genus *Morus* placed under tribe Moreae.

The tribe Moreae comprising of 10 genera and 80 species are widely distributed in the temperate, subtropical, or tropical regions of the world and can grow in a wide range of climatic, topographical, and soil conditions (Krishna et al., 2018; Rohela et al., 2020). Based on the Plants of the world online database, *Morus* comprises of 20 species with a world-wide cosmopolitan distribution. The majority of the species occur in sub-tropical to tropical climatic zones. In India, this genus is represented by five species such as *Morus alba*, *M. indica*, *M. macroura*, *M. serrata* and *M. nigra*. Historically, this genus has been used in sericulture throughout the world (Natić et al., 2015) and is famous for its nutritional benefits and medicinal values (Priya, 2012; Krishna et al., 2018). Apart from being the sole food plant of mulberry silkworm (*Bombyx mori*), *Morus* is also beneficial as food, fodder, fuel, and fiber. *Morus* fruit is also used to treat weakness, dizziness, tinnitus, fatigue, anemia, and incontinence (Tikader and Vijayan, 2010; Pham et al., 2017; Krishna et al., 2018).

The fossil record of Moraceae, based on pollens, fruits, wood remains, and leaves, has a long geological history, with the diverse and abundant record from the Cenozoic sediments of Asia (Prasad, 1990; Li and Zheng, 1995; Li and Zheng, 1995; Sun et al., 1995; Prasad and Awasthi, 1996; Konomatsu and Awasthi, 1999; Singh and Prasad, 2008; Srivastava et al., 2011; Prasad et al., 2013; Huang et al., 2018). However, to date, no fossil *Morus* has been reported from Asia. The lack of fossil evidence limits the understanding of the diversification and evolution of *Morus* in Asia. Leaf and fruit remains of *Morus* have been reported only from the Paleocene and Oligocene sediments of USA, North America (MacGinitie, 1953; Brown, 1962; Becker, 1960, 1961; Taylor, 1990). From this point of view, our discovery of *Morus* leaf remains from the early Eocene of India is remarkable and constitutes the first recognition of this mulberry genus from the Cenozoic sediments of Asia. Our retrieved fossil specimens from Gurha lignite mine represent that *Morus*, the comparable modern form of fossil specimens, was once widespread in the area. Nevertheless, this genus is now extinct in the vicinity of the fossil locality and is restricted to other distant climatologically favorable areas of India. We aim to determine the climatic changes that have drastic effects on the vegetation cover of the region in time and space and discuss the possible causes of the disappearance of this taxon from the present-day vegetation of the fossil locality.

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A new species of Indian kino tree from the Early Eocene forests of northwestern India

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Two impressed leaflet remains described here as a new species *Pterocarpus emarginaticus* Patel, Rana and Khan sp. nov., showing close resemblance with the extant leaflets of *Pterocarpus marsupium* Roxb. (Fabaceae), commonly known as the Indian kino tree, have been recorded from the Early Cenozoic sedimentary sequences of the Gurha opencast lignite mine (Early Eocene, Palana Formation), Rajasthan, northwestern India. The diagnostic macromorphological characteristics of the fossil leaflets are elliptical to obovate shape, microphyll size, acute base, characteristic emarginate apex, pulvinate petiolule, entire margin, *brochidodromous* secondary veins, presence of thin intersecondary veins and reticulate tertiary veins. This is reliable fossil evidence of leaflets similar to modern *P. marsupium* from India and abroad. The occurrence of this species and the earlier reported angiosperm, including Fabaceae taxa from the same formation, suggest the existence of a tropical, warm and humid climate during deposition.

Keywords: Fossil leaflets, opencast mine, *Pterocarpus emarginaticus*, *Pterocarpus marsupium*, sedimentary sequences.

PTEROCARPUS Jacq. is a pantropical tree belonging to the family Fabaceae, subfamily Papilionoideae and tribe Dalbergieae[1,2]. The genus is subdivided into two groups based on

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Diversified Early Eocene floral and faunal assemblage from Gurha, western Rajasthan: Implications for palaeoecology and palaeoenvironment

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ABSTRACT

Here we report a record of well preserved and diversified fossil leaves and insect impressions which was previously unknown from the early-Eocene sedimentary sequences of Gurha Lignite Mine, Western Rajasthan, India. A detailed morphotaxonomical study on these fossil leaves revealed the occurrence of a variety of floral assemblages consisting of several phytogeographically and palaeoclimatically significant taxa such as *Clausena* (Rutaceae), *Ficus* (Moraceae), *Grewia* (Malvaceae), *Eugenia* (Myrtaceae), *Ziziphus* (Rhamnaceae), *Mangifera* (Anacardiaceae) and *Lagerstroemia* (Lythraceeae). The overall floral assemblage suggests the prevalence of tropical warm and humid climate during the deposition of the sediments which was suitable for the existence of moist deciduous to evergreen forests. Certain fossil insect impressions have also been reported for the first time such as Ephemeroptera (Mayfly *naiad*), Baetidae (wing) and Hymenoptera (Formica) from Western Rajasthan. These insects aim to achieve higher temperature for their survival, suggesting prevalence of a tropical and warm environmental condition during the early-Eocene. Such floral and faunal elements indicate co-existence and abundance of the biota in this locality.

Key-words: Fossil flora and fauna, Gurha mine, Rajasthan, Early Eocene, palaeoecology, biogeography

INTRODUCTION

Among all the Paleocene-Eocene sedimentary sequences occurring in various localities of India, the Palaeocene-Eocene Palana Formation is itself unique for its highly diversified floral records. The recovered floral assemblages are of great interest, particularly for terrestrial plant fossil records. The studied Gurha open-cast lignite mine is situated about 70 km southwest of Bikaner (72°.52'10.38" E, 27°52'32.06" N). Previously, a good amount of plant fossils comprising fossil leaves, fruits and macro and micro floral assemblages have been recorded from the Gurha open cast lignite mine (Shukla *et al*., 2014b, Kumar *et al*., 2016). Vertebrate fishes as well as impressions of the certain insects (spider, mayfly, etc) in the shale sedimentary section have also been reported (Patel *et al*., 2018). In view of their biostratigraphic implications and their thermal power generation these deposits of the lignite associated sedimentary sequences are highly significant. The lignite deposit of the Gurha open cast mine comes under the Palana Formation of Early Eocene age.

Prior to this work, palaeobotanical studies have been done by Shukla *et al.* (2014 a, 2014b, 2014c,

Equus cf. Sivalensis from the Tatrot Formation (Upper Pliocene) of Jhil- Bankabara area Sirmaur district, Himachal Pradesh, India

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A partial skull of *Equus cf. sivalensis* is recovered from the medium to coarse grain, compact sandstone bed of Tatrot Formation (Saketi Formation, Upper Pliocene) of the Upper Siwalik, Jhil-Bankabara area (77°25'09.72" and 30°28'27.07") of Sirmaur district, Himachal Pradesh, India during the field work in March, 2017 (Fig. 1). The materials consist of well-preserved partial portion of skull along with left and right maxilla having P^1 to M^3 dentition. The P^1 is absent in right maxilla (Fig. 2). The check teeth are slightly curved hypsodont, well preserved with thick enamel pattern and well silicified. The P^1 is oriented parallel to the anterio - lingual side of P^2 and is simple without cusp. The P^2 and M^3 are triangular in shape and P^3 to M^2 are squarish shape. The protocone is not isolated in all cheek teeth as in *Hipparion* Species. P^2 is the largest tooth and having smallest, broad and sub triangular protocone. The other cheek teeth have Sub elliptical (P^3, P^4, M^1 and M^2) and lanceolate (P^4) shape of protocone. M^3 has longest protocone followed by P^4, M^2, M^1 and P^3. The pli-caballin is well preserved with well distinct enamel boundary, bilobed except P^4 which have multilobed. The pre-fossette and post-fossette are variable shape and size in each tooth and have complete boundary. The posterior enamel boundary of pre-fossette in P^3, P^4, M^1 and M^2 are multilobed while in P^2 and M^3 have bilobed. The anterior and posterior enamel boundary of post-fossette is bilobed in all check teeth (Fig. 2). The paracone and metacone are well developed, deep, broad, small and distinct in molars but in premolar, they are shallow and elongated. The hypoconal groove is also distinct in all cheek teeth. The anterior and posterior interstylar faces are concave in all premolar while anterior interstylar faces are concave and posterior interstylar faces are slightly convex in M^1 and M^2 and M^3 have nearly straight. The present species *E.* cf. *Sivalensis* in general have close morphological affinity *Equus sivalensis* and *E. namadicus* except in size but on detail comparison with the occlusal view and enamel pattern in the present species differs from *E. sivalensis* by protocone, pre-fossette and post-fossette shape and borders are more complex; anterior

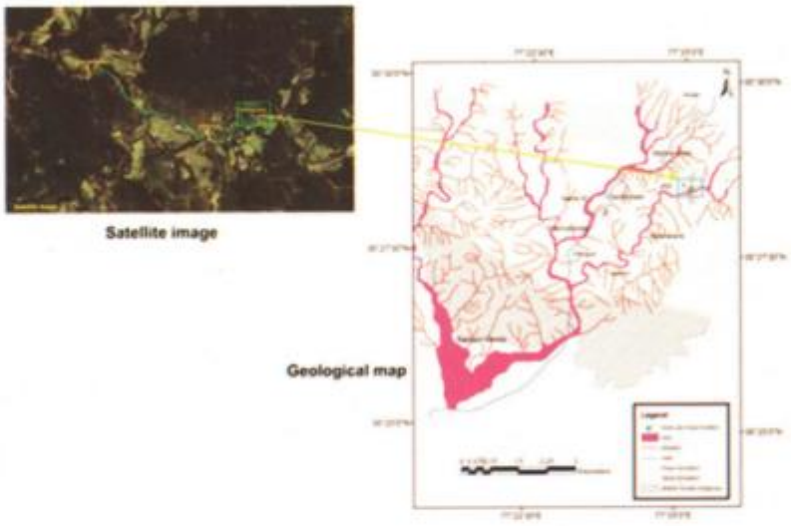

Fig .1 Location and geological map

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Limb elements of *Cervus* sp. from Lower Karewa Formation of Jammu and Kashmir, India, comments on functional morphology and palaeobiogeography

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JPSI

Limb bones of *Cervus* sp. have been recovered for the first time from the lower Karewa Formation (Hirpur Formation) exposed along the River Romushi, Khaigam, Pakharpora, Budgam District, Jammu and Kashmir, India. The 28 main morphological characters of present fossil tibia, astragalus, calcaneus, cubionavicular, ectomesocueiform and metatarsal have been selected to compare with the fossils and recent limb bones of eleven species of Cervidae, including *Cervus elaphus* (red deer), *Odocoileus hemionus* (mule deer), *O. virginianus* (white-tail deer), *Dama dama* (fallow deer), *Capreolus capreolus* (roe deer), *Muniaeus reevesi* (Reeve's muntjia), *Hydropotes inermis* (Chinese water deer), *Alces alces* (moose deer), *Megaloceros giganteus* (Irish elk deer), *Cervalces* sp. (Elkmoose deer), *Arvernocrous ardei*, and three outgroup taxa, such as Giraffidae, Bovidae and Camelidae. It shows that the maximum characters of limb bones have close affinities with the *Cervus elaphus* and presumably, these bones refer to *Cervus* sp. The study also suggests that the Cervidae originated from Eastern Eurasia/ Asia in the late Oligocene or early Miocene and migrated to Europe and the Indian subcontinent during the Middle Miocene. The functional morphology (ecomorphology) of limb bones supports the hypothesis that the *Cervus* sp. have had a cursorial habitat and lived in an open forest (forest and grassland).

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INTRODUCTION

The Kashmir Valley is bounded in the north by the Main Great Himalayan Range and the southern sides by the Pir Panjal Range, which evolved during the late Cenozoic time uplift of the Pir Panjal Range. The ancient drainage system has been blocked due to the uplift of the Pir Panjal Range, resulting in the development of a large basin (Karewa Basin). The basin received by the thick sequence of glaciolacustrine sediments of the Karewa Group, which came from the higher Himalayan ranges (Godwin-Austin, 1859; Wadia, 1941; Farooqui and Desai, 1974; Burbank and Johnson, 1982, Agrawal *et al.*, 1985, 1989; Kusumgar *et al.*,1985; Agrawal and Agrawal, 2005).

The initial geological investigation was done by De Terra and Paterson, 1939, followed by several workers and divided Karewa into two lithological units, which are lower Karewa (Hirpur Formation) and Upper Karewa (Nagum Formation), separated by an angular unconformity (Bhatt, 1976; Singh, 1982; Burbank and Johnson, 1982, 1983; Pant *et al.*, 1978; Burbank, 1983; Agrawal *et al.*, 1989). Later, Kent (1989) divided the Karewa Group into three formations: Hirpur, Nagum, and Dilpur formations. The Hirpur Formation consists of green to brown grey mud, light grey sandy clay, fine to coarse-grained sand, conglomerate, thin bands of lignite and lignitic clay. The Nagum Formation is made up of fine to coarse-grained sand and ochre sandy clay, ochre and cream coloured marl and gravel. The Dilpur Formation mainly consists of a brown silt (Fig. 1).

De Terra reported the initial vertebrate fauna from the Karewa Group, 1934 (in Pasco, 1973) followed by others Hora, 1937; Badam, 1968, 1972; Tripathi and Chandra 1972; Tiwari and Kachroo, 1977; Sahni, 1982; Bhatia, 1982; Sahni and Kotlia, 1985; Kotlia, 1990; Kotlia *et al.*, 1982. The invertebrate fauna, such as ostracodes, bivalve and gastropods, as well as the plant fossils such as charophytes, pollens, spores and diatoms, were described by several workers (Bhargava, 2015, reference therein).

The age of the Hirpur Formation has been suggested to be early Pliocene-Pleistocene by Bhatia et al. (1998) based on diagnostic charophyte flora such as *Nitelopsis megarensis, Lychnothammus brbatus, Chara globularis,* and *C. vulgaris.* The palaeomagnetic and fission track dating of volcanic ash beds of different sections have carried out by several workers and suggested an age of 2.4 ± 0.3 Ma (Burbank and Johnson,

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Original article

A new basal raoellid artiodactyl (Mammalia) from the middle Eocene Subathu Group of Rajouri District, Jammu and Kashmir, northwest Himalaya, India ☆

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ABSTRACT

A new artiodactyl of moderate size, *Rajouria gunnelli* nov. gen., nov. sp., is described on the basis of several dentaries, maxillae and isolated teeth from the middle Eocene Subathu Group of the Kalakot area, Rajouri District, Jammu and Kashmir, India. Despite its general resemblance with the family Dichobunidae by the retention of a paraconid on m1-2 and a simple P4 where endocristids do not form an anterior loph, this taxon shares with Raoellidae two unambiguous characters: the presence of a hypoconid on p4, and an asymmetrical P4. The phylogenetic position of the new taxon within the Cetacea–Raoellidae clade is strongly supported by seven non ambiguous synapomorphies, among which a cristid obliqua on lower molars anteriorly pointing towards the postectoprotocristid, and a P3 with only two roots. The presence of a new basal raoellid in the middle Eocene Subathu Group sheds new light on the phylogeny and paleobiogeography of raoellid artiodactyls.

1. Introduction

Artiodactyls are the most common medium-sized mammals in the middle Eocene of the Indian subcontinent and Southeast Asia. The middle Eocene Subathu Group in northwest Himalaya is one of the most important geological units in India that is known for artiodactyls, especially Raoellidae. This family is important in the evolutionary history of cetartiodactyls because it is closely related to Cetacea (Thewissen et al., 2007). So far, raoellids have been described by several authors from localities such as Kalakot, Sindkhatuti, Chenpur, Tatapani, West Babbian Gala, East Babbian Gala, Moghala (or Moghla or Mougla), all in Rajouri (or Rajauri) District of Jammu and Kashmir and from the type area of Subathu in Himachal Pradesh (Ranga Rao, 1971; 1972; 1973; Sahni and Khare, 1971; Kumar and Sahni, 1985; Thewissen et al., 2007). They have been first related to different families of artiodactyls before they were given their own familial status by Sahni et al. (1981). Presently, raoellids are represented by four genera: *Indohyus*, *Khirtharia*, *Kunmunella*, and *Metkatius* (Kumar and Sahni, 1985).

In this paper, we describe a new medium size raoellid artiodactyl on the basis of nearly complete upper and lower dentition, recovered from a new fossil locality located near the village of Aiji, Rajouri District, Jammu & Kashmir. The new locality, named East Aiji-2 (see Waqas and Rana, 2020), was discovered in 2017 by one of us (MW) ca. 2 km away from East Babbian Gala (Fig. 1). It yielded raoellid skulls, dentaries, maxillae, postcranial elements, and numerous isolated teeth.

Raoellidae are mainly documented from the middle Eocene of India. However, they are also known from the Kuldana Fm. in Lammidhan and Ganda Kas (Punjab Province) and Chorlakki (Kohat District, North-West Frontier Province) in Pakistan (Dehm and Oettingen-Spielberg, 1958; West, 1980; Thewissen et al., 1987), and from Shanghuang fissure B, Jiangsu Province in China (Metais et al., 2008; Orliac and Ducrocq, 2012). The well-preserved remains of the new raoellid from the Kalakot area provides new information on the morphological characters, phylogeny, and paleobiogeographic implications of the family.

2. Geological setting

The geology of the Subathu Group of the Kalakot area, northwest Himalaya has been described and discussed since nearly

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PALÆO VERTEBRATA

ARTICLE

Additions to the elasmobranch assemblage from the Bandah Formation (middle Eocene, Bartonian), Jaisalmer District, Rajasthan, India, and the palaeobiogeographic implications of the fauna

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Abstract: Isolated elasmobranch teeth (sharks and rays) from the middle Eocene (Bartonian) Bandah Formation in the Jaisalmer District of Rajasthan, India are described. The remains improve our knowledge of the environment represented by this lithostratigraphic unit and the ecology preserved therein. Seventeen unequivocal taxa were identified, including *Nebrius* sp., *Striatolamia* aff. *S. macrota*, *Brachycarcharias atlasi*, *B. lerichei*, cf. *Jaekelotodus* sp., *Carcharhinus mancinae*, *Rhizoprionodon* sp., *Physogaleus* sp., *Galeocerdo clarkensis*, *G. eaglesomei*, *Odontorhytis* aff. *O. pappenheimi*, "*Rhinobatos*" sp., "*Dasyatis*" sp., *Coupatezia* sp., "*Aetomylaeus*" sp., "*Rhinoptera*" sp., and *Ouledia* aff. *O. lacuna*. Of these, "*Aetomylaeus*" sp., *B. atlasi*, *C. mancinae*, *G. clarkensis*, *G. eaglesomei*, cf. *Jaekelotodus* sp., *Nebrius* sp., *Odontorhytis* aff. *O. pappenheimi*, *Ouledia* aff. *O. lacuna*, and "*Rhinoptera*" sp. are reported from the middle Eocene of India for the first time. The Bandah Formation elasmobranch palaeofauna has close affinities to the Palaeocene-Eocene Tethyan/Paratethyan faunas of Africa, Madagascar, Asia, and Europe, and some taxa indicate a western hemisphere influence from North America. The Bandah Formation palaeofauna indicates that deposition occurred in a moderately shallow marine environment. The Bartonian age is primarily based on foraminifera but is corroborated by the presence of elasmobranch taxa that also occur in contemporaneous deposits elsewhere. The marine regression started during the early Palaeogene, and our study indicates that the sea completely withdrew from the Jaisalmer Basin after the deposition of the Bandah Formation. This event may have been synchronous with the middle Eocene uplift of the Himalayan-Tibetan Plateau.

Keywords: Palaeogene, Chondrichthyes, Elasmobranchii, South Asia, Indian Ocean

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INTRODUCTION

The Palaeogene basin of the Jaisalmer District in Rajasthan, India has long been recognized for its rich diversity of fossil invertebrates, but vertebrate fossils from the region are comparatively poorly known (Kumar *et al*., 2007; Pandey *et al*., 2018; Kumar *et al*., 2017; Kumar *et al*., 2020). The paucity of studies on the vertebrate fossils in this region is due to a combination of factors, one being the poor state of preservation of much of the material. Of the few published studies on fossil vertebrates from the Jaisalmer District, Kumar *et al*. (2017) and Kumar *et al*. (2020) described small vertebrate faunas from the middle Eocene Bandah Formation in Rajasthan. Kumar *et al*. (2017) identified teeth as *Isurus* sp., *Lamna* sp., *Striatolamia* sp. and *Galeocerdo* sp., and Kumar *et al*. (2020) reported the occurrence of *Isurus* cf. *I. oxyrhinchus*, *Carcharias* cf. *C. tricuspidatus*, *Galeocerdo* sp., and *Myliobatis* sp. These preliminary reports are of interest because the fossils were obtained from the same locality and formation as the present study, but the material was surface collected from a different outcrop where the lithologic beds are more difficult to discern.

Outside of the Jaisalmer District, several Palaeogene elasmobranch faunas have been reported from the Indian subcontinent, the oldest of which occur in upper Palaeocene (Thanetian) to lower Eocene (Ypresian) strata of the Akli and Kapurdi formations in the Barmer District of Rajasthan (Rana *et al*., 2005, 2006; Rajkumari & Prasad, 2020), and the similarly-aged Kakara Formation of the Shimla District in Himachal Pradesh (Gupta & Kumar, 2013). Early Eocene elasmobranch faunas have been documented from the Cambay Shale of the Surat District (Rana *et al*., 2004), the Subathu Formation of the Solan District of Himachal Pradesh (Sahni *et al*., 1984; Kumar & Loyal, 1987), Nilkanth of the Pauri District of Uttarakhand (Kumar, 1989) and Rajouri District of Jammu and Kashmir (Khare, 1976). Additional selachian faunas were described by Sahni & Mishra (1975) from various Eocene units in the Kutch District in Gujarat.

Herein we describe a collection of isolated elasmobranch teeth recovered *in situ* from the Bandah Formation in the Jaisalmer District of Rajasthan that were obtained during a field investigation in the region in February 2020. These specimens are described in detail, and we provide a re-evaluation of the elasmobranch remains previously reported from the locality by Kumar *et al*. (2017) and Kumar *et al*. (2020). Additionally, we discuss taxonomic issues and the palaeobiogeographic distributions of the species we identified, and we provide a palaeoenvironmental interpretation for the fossiliferous horizon based on the fossils that have been collected.

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New fossils from Tadkeshwar Mine (Gujarat, India) increase primate diversity from the early Eocene Cambay Shale

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ABSTRACT

Several new fossil specimens from the Cambay Shale Formation at Tadkeshwar Lignite Mine in Gujarat document the presence of two previously unknown early Eocene primate species from India. A new species of *Asiadapis* is named based on a jaw fragment preserving premolars similar in morphology to those of *A. cambayensis* but substantially larger. Also described is an exceptionally preserved edentulous dentary (designated cf. *Asiadapis*, unnamed sp. nov.) that is slightly larger and much more robust than previously known Cambay Shale primates. Its anatomy most closely resembles that of Eocene adapoids, and the dental formula is the same as in *A. cambayensis*. A femur and calcaneus are tentatively allocated to the same taxon. Although the dentition is unknown, exquisite preservation of the dentary of cf. *Asiadapis* sp. nov. enables an assessment of masticatory musculature, function, and gape adaptations, as well as comparison with an equally well-preserved dentary of the asiadapid *Marcgodinotius indicus*, also from Tadkeshwar. The new *M. indicus* specimen shows significant gape adaptations but was probably capable of only weak bite force, whereas cf. *Asiadapis* sp. nov. probably used relatively smaller gapes but could generate relatively greater bite forces.

1. Introduction

The early Eocene primate fauna of India is known so far only from the Cambay Shale Formation, which is exposed in open-cast lignite mines in Gujarat, west central India. Our understanding of these Indian primates has been based almost entirely on the extensive sample from Vastan Lignite Mine, which includes about 100 specimens (dental and postcranial) representing at least four taxa—the asiadapid adapoids *Marcgodinotius indicus* and *Asiadapis cambayensis*, and the omomyids *Vastanomys gracilis* and *V. major* (Bajpai et al., 2005; Rose et al., 2007, 2009; Dunn et al., 2016). Recently we reported a small number of primates from the Cambay Shale at Tadkeshwar Lignite Mine, about 10 km southwest of Vastan Mine (Smith et al., 2016). These fossils, from two stratigraphic levels, were referred to *M. indicus* (two tooth-bearing dentaries) and cf. *Asiadapis cambayensis* (an edentulous dentary). Notably, one of the jaws of *M. indicus* comes from the lower level, stratigraphically slightly higher and thus probably slightly younger than the Vastan fossils, whereas the second comes from the higher level, about 12 m above the lower level and therefore certainly younger, although how much younger is still unknown and controversial. Both specimens of *Marcgodinotius* are close enough morphologically to the Vastan sample to justify allocation to the same species, although the higher specimen is derived in showing slight compression and a possible reduction in number of anterior premolars.

Here we describe several new primate specimens from Tadkeshwar mine, which indicate the presence of two previously unrecognized primate species from the Cambay Shale. This increase in diversity is further evidence that India played an important role in the evolution of primates early in their history.

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Palaeogene Fish Otoliths from Lignite Associated Succession (Cambay Formation) Khadsaliya, Bhavnagar, Gujarat, India

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Abstract

Ten genera and seventeen species of teletostean taxa of otoliths were recovered from the Khadsaliya clays (Cambay Formation) exposed in Khadsaliya open cast lignite mine, Bhavnagar, Gujarat. This was done by screening and washing of ~500kg rock matrix of which ten species are new *viz*. *Palaeogadus elongatus* sp. nov., *P. lanceolatei* sp. nov., *Ampheristus bhavnagarensis* sp. nov., "genus *Batrachiodidarum" eocenous* sp. nov.," genus *Opisthognathid" sahnii* sp. noZZZv., "genus *O". khadsaliyensis* sp. nov., *Apogon nolfi* sp. nov., *A. closeostiumus* sp. nov., *A. cambayenensis* sp. nov. and "genus *Uranoscopidarum" ellipticus* sp. nov. The present day relative of these represented taxa occurs in the marine realm while some of them penetrate into fresh water such as pristigasterids, atherinids, centropomids, ambassids and ophidiids but the primary freshwater fishes are absent. The present taxa are mainly confined to tropical, subtropical, very shallow, near shore habitat and the mesopelagic and deep water bottom fishes are also absent. In general, the present fish taxa suggests a protected shallow marine environment and not widely exposed ocean realm and may be regular influx of fresh water or may be estuarine of protected bay.

Keyword: Otoliths, Teleost, Palaeogene, Maceration, Bhavnagar, India.

Introduction

The work on Palaeogene fish otoliths from India is extremely poor and the pioneer studies on the Indian and south Asiatic realm were started by Sahni and Saxena (1982) from the middle Eocene of Kutch. Nolf (991) reported otoliths from the middle to late Eocene Khirtar Formation of Pakistan, followed by a more substantial work on middle Eocene otoliths from India and Java (Nolf and Bajpai, 1992). Samant and Bajpai (2001) tentatively documented six taxa of otoliths at the familial or sub-ordinal level from the early Eocene of Cambay Formation, Gujarat. Bajpai and Kapur (2004) described two species of gobioids otoliths from Cambay Formation at the Vastan lignite mine. Nolf *et al*. (2006) carried out detailed studies on otoliths from the Cambay Formation of Vastan and described 20 species of otoliths.

The Saurashtra peninsula is mainly covered by Deccan Trap basaltic lava flows, which is overlying Mesozoic sediments in the north and underlain by the Tertiary and Quaternary sediments at the coastal fringe. The southern part of Saurashtra peninsula is bounded by sea except north east, where it is flanked by alluvium plain and the formations are ranging in age from Cretaceous to Recent coastal deposits (Fig. 1). Deccan Trap formed the basement for the deposition of Palaeogene and Neogene sediments, which have mainly subsurface exposure. But at some places in the basin, it is found in thin strips, on the west coast near Gogha and Khadsaliya and on the east side of gulf at Vagadkhol/Olpad over the Deccan traps and comprises the oldest sediments (Paleocene-lower Eocene). It is overlain by thick sequence of clays comprising whitish-grey clay and greenish-grey shale/clay with lignite seams. The lignite bearing shale/clay is referred as Khadsaliya clays (Srivastava, 1963; GHCL, 2008; Thakur *et al*., 2010), which is equivalent to the Cambay Formation of the type area Cambay Basin.

Palaeontological investigation of Khadsaliya clays was carried out in 2008 and otolith fauna was recovered from the greenish-grey shale bed of Khadsaliya clays lying above the top coal seam. Garg *et al*. (2014) reported dinoflagilate cyst assemblages like *Homotryblium tenuispinosum, Cordosphaeridium fibrospinosum, C. exilimurum* and *Muratodinium fimbriatum* from the greenish-grey shale lying above the top coal seam and suggested Thanetian to Yepresian age for the greenish-grey shale bed, but not younger than middle Lutetian.

PalZ
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RESEARCH PAPER

Mastication and enamel microstructure in *Cambaytherium*, a perissodactyl-like ungulate from the early Eocene of India

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Abstract

The dentition of *Cambaytherium* was investigated in terms of dental wear, tooth replacement and enamel microstructure. The postcanine tooth row shows a significant wear gradient, with flattened premolars and anterior molars at a time when the last molars are only little worn. This wear gradient, which is more intensive in *Cambaytherium thewissi* than in *Cambaytherium gracilis*, and the resulting flattened occlusal surfaces, may indicate a preference for a durophagous diet. The tooth replacement (known only in *C. thewissi*) shows an early eruption of the permanent premolars. They are in function before the third molars are fully erupted. During the dominant phase I of the chewing cycle the jaw movement is very steep, almost orthal, with a slight mesiolingual direction and changes into a horizontal movement during phase II. The enamel microstructure shows Hunter-Schreger-bands (HSB) in the inner zone of the enamel. In some teeth the transverse orientation of the HSB is modified into a zig-zag pattern, possibly an additional indicator of a durophagous diet.

Keywords *Cambaytherium* · India · Eocene · Early perissodactyla · Tooth wear · Tooth replacement · Wear gradient · Hunter-Schreger bands · Durophagy · Zig-zag enamel

Introduction

Cambaytherium is an early Eocene ungulate from the Cambay Shale Formation of Gujarat, India (Bajpai et al. 2005, 2006; Rose et al. 2006, 2014). It is characterized by a full placental dental formula (3-1-4-3/3-1-4-3) and bunodont molars that often have accessory cuspules but little crest development. The incisors are small and relatively spatulate, the canines unreduced, and the premolars relatively simple, except for p4, which is variably semimolariform. A number of features, including the distinctive saddle-shaped navicular facet of the astragalus (Radinsky 1966), indicate affinity with perissodactyls, but many features are more primitive than in any known perissodactyl, and phylogenetic analyses place cambaytheriids as the sister group of Perissodactyla (Rose et al. 2014).

Because of its pivotal phylogenetic position and its unexpected occurrence on the drifting Indian subcontinent

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New Raoellidae (Artiodactyla) from the Subathu Group (Middle Eocene), Rajouri District, Jammu and Kashmir, India and their significance

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Abstract: Two species of raoellid artiodactyls *Metkatius babbiangalensis* sp. nov. and *Khirtharia* cf. *dayi* are reported on the basis of upper and lower molars recovered from the red-maroon-grey shale bed of Subathu Group, Rajouri District of Jammu and Kashmir. *M. babbiangalensis* sp. nov. is characterised by metaconid placed slightly higher than protoconid and hypoconulid being the smallest cusp in the talonid basin. The prehypocristid (cristid obliqua) is directed towards postectoprotocristid at the protoconid base and the anterior cingulum is well developed. The upper molars are squarish, paraconule feebly developed, endometacristule and postmetacristule faintly developed and endometacristule and endometacrista form transverse crest but the premetacristule is absent. *Khirtharia cf. dayi* is characterised by reduced hypoconulid lobe in m3; low bulbous bunodont cusps; smooth enamel surface, moderate size, wider trigonid basin, distinct cristid and cristids outline as squarish as in *Khirtharia dayi*. The upper molars are faintly developed; reduced metacone in M3, which is even smaller than metaconule; distally open trigon basin lacking lingual cingulum. The presence of a new species from Subathu throws light on palaeobiogeographic implications during the collision of the Indian and Asian plates.

Keywords: Mammalia, Artiodactyla, Raoellidae, middle Eocene; Subathu Group; India.

INTRODUCTION

In the northwestern region of the Indian Subcontinent, the middle Eocene sequence of Subathu Group of Kalakot area is well known for one of the richest and most diverse mammalian fauna. A number of workers have described the mammalian fauna from the Subathu sequence of Kalakot region such as; Ranga Rao 1971b, 1972, 1973; Ranga Rao & Misra 1981; Ranga Rao & Obergfell 1973; Khan 1973; Sahni & Khare 1971, 1973; Kumar 1991, 1992, 2000; Sahni & Srivastava 1976, 1977, 1978; Kumar & Jolly 1986; Kumar & Sahni 1985; Kumar *et al.* 1997a, b, 2002; Srivastava & Kumar 1996; Thewissen *et al.* 2007, 2009; Cooper *et al.* 2014. The known fossiferous localities in Kalakot area are Bali, Jagni, Sindkhatuti, Khargala, Chenpur, Tattapani, East and West Babbian Gala, Moghala, and Triyath of Rajouri District, Jammu and Kashmir. The mammalian fauna from the Subathu Group of Kalakot area is represented by Rodentia, Creodonta, Primates, Artiodactyla, Cetacea, Perissodactyla and Paenungulata (Proboscidea), and the artiodactyls are the most common and diverse mammals, followed by rodents and perissodactyls. Raoellidae is represented by the four genera and five species, viz., *Khirtharia inflatus, Metkatius kashmiriensis, Kunmunella transversa, Kunmunella kalakotensis* and *Indohyus indirae*. In Pakistan to the west of the Kalakot localities, Eocene mammalian fauna is also known from the Kuldana and Chorlakki Formations of Ganda Khas and Chorlakki areas (Hussain *et al.* 1978; Gingerich *et al.* 1979; Thewissen 1987 and Thewissen *et al.* 2001). Similarly, Raoellidae species have also been reported from the middle Eocene Shanghuang, China (Métais *et al.* 2008) who first described it as the oldest suoid but later re-identified it as a raoellid which is the first report of raoellids from outside the Indian subcontinent (Orliac & Ducrocq 2012).

In the present paper, we describe two species (one new) of Raoellidae from a new locality (east Aiji-2; 33° 29' 48"N: 74° 29' 04"E) which is situated 3 km north east of earlier known locality of East Babbian Gala (Fig. 1) and are represented by *Metkatius babbiangalensis* sp. nov. and *Khirtharia* cf. *dayi* on the basis of fragmentary dentary and maxilla. *K. dayi* is known from Kuldana Formation of Pakistan and in India. Sahni & Khare 1973 have also described it from Subathu sequence of Kalakot. However, later Kumar & Sahni 1985 assigned the Indian species to *Khirtharia inflatus*. *K.* cf. *dayi* is morphologically slightly different from *K. dayi* so, we assigned the specimen as *K.* cf. *dayi*. The report of new species from the Subathu sequence provide new palaeobiogeographic and systematic interpretations.

The geology of Kalakot region in northwest Himalaya has been illustrated by various workers (Middlemiss 1929; Wadia 1928; Pascoe 1964; Bhandari & Agarwal 1966; Karunakaran & Ranga Rao 1979 and Singh 2000). The general geological sequence of the area is exposed in the form of three inlier structures viz. Kalakot, Metka and Moghala of which the Kalakot is the largest. The basement sequence is Sirban Limestone of Precambrian age which is overlain by the Subathu sequence and consists of carbonaceous shale intercalated with sub-anthracitic coal seams, olive-green shale alternating with thick foraminiferal limestone, grey-red ossiferous siltstone, shelly limestone, and purple to grey colour fossiliferous shale. The top of Subathu sequence is green sandstone which is overlain by the lower Murree Formation. In Kalakot inlier, a thick layer of chert –breccia is present between Sirban Limestone and Subathu sequence while its absent in Moghala and Metka inliers (Kumar & Sahni 1985). The present locality falls in the Moghala inlier which consist of variable colour of shales, claystones, and sandstones of middle Eocene age and are overlain by lower Murree Formation of late Oligocene-early Miocene age (Fig. 1). The red, maroon to grey colour shale and siltstone of the Subathu sequence yields most of the vertebrate fossils. The age of Subathu Group has been assigned to middle Eocene on the basis of foraminifera by Mathur *et al.* 1978.

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AN ENIGMATIC NEW UNGULATE-LIKE MAMMAL FROM THE EARLY EOCENE OF INDIA

by SHAWN P. ZACK[1,2], KENNETH D. ROSE[3], LUKE T. HOLBROOK[4], KISHOR KUMAR[5], RAJENDRA S. RANA[6] *and* THIERRY SMITH[7]

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Abstract: We report a new genus and species of herbivorous mammal, *Pahelia mysteriosa*, from the early Eocene Cambay Shale Formation, Tadkeshwar Lignite Mine, Gujarat, India. The new taxon, approximately the size of a small phenacodontid (e.g. *Ectocion parvus*), is represented by three mandibular fragments, the most complete of which documents nearly the entire symphysis and mandibular body plus P_3–M_3. *Pahelia* has incipiently selenolophodont molars with strong exodaenodonty, absent paraconids, weak but distinct entolophids, and prominent ectostylids. Molar size increases distally, but M_3 does not develop a prominent third lobe. Premolars are simple, with prominent protoconids and short talonids but little development of other trigonid cusps. The mandibular symphysis is strongly fused, and there is an enlarged alveolus for an anterior tooth. The combination of features present in the new taxon does not closely match that of any known mammal, but there are some similarities to a diversity of ungulates from Africa, Asia, Europe and North America. Preserved morphology is insufficient to assess the affinities of the new taxon with confidence, but a link to Quettacyonidae, also endemic to the Indian subcontinent, is morphologically and biogeographically plausible. If this scenario is correct, it suggests that *P. mysteriosa* could be a part of the endemic mammalian fauna of India prior to its initial faunal contact with Asia.

Key words: Mammalia, Eutheria, ungulate, Eocene, Cambay Shale Formation, India.

THE Cambay Shale Formation has produced the richest, most diverse terrestrial vertebrate fauna from the early Eocene of India. Mammals are particularly well documented and include the earliest representatives of Artiodactyla, Perissodactyla, Primates, Rodentia, Lagomorpha, Chiroptera, Lipotyphla, Hyaenodonta and Tillodontia known from the Indian subcontinent (Bajpai *et al.* 2005*a*–*c*, 2006, 2007, 2008, 2009; Rose *et al.* 2006, 2007, 2008, 2009*a*, *b*, 2013, 2014; Smith *et al.* 2007, 2015, 2016; Rana *et al.* 2008, 2015; Kumar *et al.* 2010; Kapur & Bajpai 2015; Dunn *et al.* 2016; Kapur *et al.* 2017*a*, *b*). Despite India's lengthy isolation from both Africa and Eurasia, the level of endemism of the Cambay Shale fauna, to date, has been relatively modest. While some groups are distinctive at the family level, particularly cambaytheriids, which are endemic to the Indian subcontinent (Ginsburg *et al.* 1999; Bajpai *et al.* 2005*a*, 2006; Rose *et al.* 2006, 2014), most groups show evidence for a relatively close relationship to taxa from North America, Europe, or mainland Asia, particularly the first two landmasses (Smith *et al.* 2007; Rana *et al.* 2008; Kumar *et al.* 2010; Rose *et al.* 2013). Even cambaytheres, although distinct and endemic, show clear affinities to early Holarctic perissodactyls (Rose *et al.* 2014).

Until recently, Cambay Shale vertebrates were primarily known from the Vastan Lignite Mine, Surat District, Gujarat State, India. Smith *et al.* (2016) recently described material from two horizons at a second locality, the Tadkeshwar Lignite Mine. The Tadkeshwar mammal assemblage is broadly similar to the Vastan fauna, sharing several species in common; differences include the presence of at least one pantodont and a small species of the cambaythere *Cambaytherium* (Smith *et al.* 2016).

The present contribution reports a new genus and species of a mammal from both horizons at Tadkeshwar (lower TAD-1, upper TAD-2). It is represented by three tooth-bearing lower jaw fragments, the morphology of which is strongly distinct from that of any previously

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Original article

Additional vertebral material of *Thaumastophis* (Serpentes: Caenophidia) from the early Eocene of India provides new insights on the early diversification of colubroidean snakes

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ABSTRACT

The Ypresian Cambay Shale Formation at Vastan, Mangrol, and Tadkeshwar lignite mines in Gujarat, western India, has yielded a rich vertebrate fauna including madtsoiid, palaeophiid, booid, and colubroidean-like snakes. The latter are particularly abundant, but their systematic affinities are difficult to resolve. Here we describe new specimens of the colubroidean-like snake *Thaumastophis missiaeni*, including anterior, middle, and posterior trunk vertebrae, as well as caudal vertebrae. The combination of primitive and derived caenophidian and colubroidean vertebral characters confirms *Thaumastophis* as the earliest known stem-colubriform snake while *Procerophis*, from the same beds, is more derived and considered to represent a crown-Colubriformes. Additionally, *Thaumastophis* shares with *Renenutet enmerwer* from the late Eocene of Egypt a unique combination of vertebral characters that suggests an exchange with North Africa was possible along the southern margin of the Neotethys. We erect the new family Thaumastophiidae for *Thaumastophis* and *Renenutet* on the basis of their shared derived vertebral morphology.

1. Introduction

The Cambay Shale Formation, exposed at the Vastan, Mangrol, and Tadkeshwar open cast lignite mines ca. 40 km northeast of Surat, Gujarat, western India (Fig. 1), is known since 2004 for its well-preserved diverse fauna of early Eocene terrestrial mammals as well as other vertebrates (e.g., Rana et al., 2004, 2005; Bajpai et al., 2005a; Rose et al., 2006; Sahni et al., 2006; Smith et al., 2016). The mammalian fauna of the Cambay Shale Formation includes the earliest modern mammals from the Indian subcontinent – with the highest diversity of early bats (Smith et al., 2007), the oldest lagomorph (Rose et al., 2008), the first Asian ailuravine rodent (Rana et al., 2008), primitive adapoid and omomyid primates (Bajpai et al., 2005b; Rose et al., 2007, 2009a; Dunn et al., 2016; Rose et al., 2018), primitive artiodactyls (Kumar et al., 2010), the earliest Indian tapiroid (Smith et al., 2015), endemic perissodactyl-like cambaytheriid mammals (Bajpai et al., 2005a; Rose et al., 2014) – as well as more archaic groups such as the first Indian tillodonts (Rose et al., 2009b, 2013) and basal hyaenodontan carnivorous mammals (Bajpai et al., 2009; Rana et al., 2015). Other vertebrates include marine and non-marine fish (Rana et al., 2004; Nolf et al., 2006), the earliest ranid and bombinatorid frogs (Bajpai and Kapur, 2008; Folie et al., 2013), acrodontan lizards (Prasad and Bajpai, 2008; Rana et al., 2013), the oldest birds of the Indian subcontinent (Mayr et al., 2007, 2010), and a high diversity of terrestrial and aquatic snakes (Bajpai and Head, 2007; Rage et al., 2008). The latter are particularly abundant and include madtsoiid, palaeophiid, booid, and colubroidean-like snakes (Smith et al., 2016).

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Assessment of Recent Tectonic Activity along the Yamuna Basin, Garhwal Region, NW-Himalaya, India: Based on Morphotectonic Analysis

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Abstract

Decoupling between climate and tectonics, transform the elevation of earth surface regionally by denudation and displacement of land. To extract the tectonic footprints on morphology of landform, geormophometry is widely accepted tool due to visible responses in Drainage architecture to an intense tectonic environment. The present morphology of Yamuna basin in the Garhwal Himalaya, India is a result of continuing crustal deformation; erosion and deposition in the area. The drainage system and geomorphic expression of topography have been significantly influenced by active tectonics in this basin. In present study, for numerical modelling to detect the influence of tectonic signals on landform, we used morphotectonic parameters, to gradient index (SL), valley floor height to width ratio (Vf), asymmetry factor (Af), basin shape index (BS) and hypsometric integral (HI), extracted from SRTM DEM with resolution of 30 m. All these morphotectonic parameters are integrated to produce an index of relative active tectonics (IRAT). The Yamuna basin is classified into three groups based on IRAT, very high (<2.0); moderate (2.0 - 2.25) and low (>2.25) based on the degree of tectonic activity. Result shows approx. 56% of Yamuna basin experience high tectonic activity. This along strike deformation pattern pronouncedly emulates subsurface geometry based tectonic model.

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Geochemical evidence for the provenance, tectonic settings and depositional environment during the Cambrian Series 2-Wuliuan (Miaolingian) from the Kunzam La Formation in the Sumna Valley, Spiti, NW Himalaya

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We present trace-element compositions and rare-earth elements (REEs) analyses of the Cambrian Series 2-Wuliuan (Miaolingian), Kunzam La Formation from the Sumna Valley, Spiti, Tethyan Himalaya, in order to identify the provenance, tectonic settings and depositional environment in the region. The trace elemental ratios (Th/Co, Th/Sc, La/Sc, Cr/Th) and REE patterns show compositions similar to the felsic composition, which are comparable with the upper continental crust, suggesting that the sediments in the Sumna Valley were derived from a felsic source that possibly lie in the felsic igneous province of the old Precambrian Indian craton. The elemental discrimination diagrams show deposition of the Sumna Valley rocks in a passive continental margin tectonic setting. The selected trace-element ratios such as V/Cr, Ni/Co, Th/U and V/V+Ni as well as positive Ce and negative Eu anomalies indicate oxidising conditions prevailed during the deposition of the Cambrian Series 2-Wuliuan (Miaolingian) rocks. The concentration of Y and Rb trace elements indicates continental sediments depositional site was proximal and close to near-shore environment. Finally, the low REE+Y and selected trace elements (La, Th, Sc, Ni, Cr, V, U, Rb, Zn, Y) concentration indicate a major transgressive event at the boundary of the Cambrian Series 2-Wuliuan (Miaolingian) associated with the *Oryctocephalus indicus* biozone.

Keywords. Trace and REE elements; Kunzam La Formation; Cambrian Series 2-Wuliuan (Miaolingian); Sumna Valley; Tethyan Himalaya.

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THEMATIC ISSUE

Interpreting land subsidence impacts due to groundwater depletion using remote sensing-based GRACE gravity anomaly and DInSAR technique: a study on north-western parts of India

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Abstract
Extraction of water reserve is at risk, especially at several locations of north-western India due to tremendous growth in populations and excessive use of water over the decade. It has been evident through this study that several regions in Punjab such as Dera Bassi, Landran, Singhpura, and Ambala in Haryana are facing constant depletion of groundwater at the rate of 46.26 cm/year, 49.16 cm/year, 120.77 cm/year and 237.69 cm/year, respectively, during 2005–2018. Whereas, depleting trends have also been analysed with derived GRACE gravity anomaly of 12.65 cm/year at respective locations. Although these areas lie in arid to semiarid zone, with moderate precipitation in the monsoon month of June–August, it does not meet the requirement of recharging the aquifer to the previous level, hence causing land deformation, which is mostly witnessing tensional, compressional and shear cracks with vertical, horizontal and diagonal orientation in nature, which further deliberated using conventional DInSAR. To identify the deformed hotspots in the affected areas, DInSAR was performed using remotely sensed Sentinal-1 SAR sensor. Additionally, to interpret the seismic consequences around the study area, pre-seismic data were examined and categorised medium intensity (in between 4.5 and 4.9 mb) earthquake, which did not affect the structures. Therefore, from the study, it was agreeable to manifest that the deformation which took place in the area is due to massive long-term extraction of groundwater.

Keywords Groundwater depletion · Land subsidence · GRACE · DInSAR · Building cracks

Introduction

Groundwater is the prime source of freshwater across the globe, existing beneath the subsurface. The present situation indicates the diminishing of freshwater resources (surface and subsurface both) due to unsustainable usage and anthropogenic practices leading to depletion, with the rapid and continuous growth of the population and demand globally. The groundwater level extraction varies globally due to unsustainable consumption for irrigation, industrialisation and other domestic uses. The assessment of the groundwater availability and consumptions in India is monitored by the Central Ground Water Board (CGWB) and the State Government agencies (CGWB 2014). Reports suggest that 71%

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Original article

A new stratigraphic occurrence of the taxon *Pagetia* (Trilobita) from the Spiti region and its biostratigraphic significance in correlation of the Wuliuan Stage (Miaolingian Series) in the Kashmir and the Spiti regions (Tethyan Himalaya), India

Une nouvelle occurrence stratigraphique du taxon Pagetia *(Trilobita) de la région du Spiti et sa signification biostratigraphique en corrélation du stade Wuliuan (série miaolingienne) dans les régions du Cachemire et du Spiti (Tethyan Himalaya), Inde*

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ABSTRACT

Abundant, though moderately well-preserved, specimens of *Pagetia* sp. are recorded along with the ptychopariid *Xingrenaspis dardapurensis* from a new stratigraphic level which lies above the *Oryctocephalus salteri* biozone in the Spiti region (Himalaya). This occurrence of *Pagetia* in a higher stratigraphic level (higher than the *Oryctocephalus salteri* biozone) from the Spiti region helps in understanding the distribution of this taxon in the Cambrian of the Kashmir and Spiti regions of the Himalaya. A *Pagetia-Xingrenaspis* association from the Kashmir region is already known, the present discovery of a similar association in the Spiti region enables the Wuliuan (Miaolingian) biostratigraphic correlation between the Kashmir and the Spiti regions. The record of the taxon *Pagetia* from a higher stratigraphic level in the Spiti region contradicts the previous assumption that the *Pagetia* bearing level in Kashmir is equivalent to the *Pagetia-Oryctocephalus indicus* (*O. indicus* biozone, Hayden horizon 2) in the lowest part of the Wuliuan in the Spiti region.

Mots clés :
Pagetia
Wuliuan (Miaolingien)
Spiti
Cachemire
Biostratigraphique corrélation

RÉSUMÉ

Des spécimens abondants, bien que modérément bien conservés, de *Pagetia* sp. sont signalés avec le ptychopariide *Xingrenaspis dardapurensis* dans un nouveau niveau stratigraphique situé au-dessus de la biozone *Oryctocephalus salteri* dans la région de Spiti (Himalaya). Cette occurrence de *Pagetia* à un niveau stratigraphique supérieur de la région de Spiti aide à comprendre la distribution de ce taxon dans les régions du Cambrien du Cachemire et du Spiti de l'Himalaya. L'association *Pagetia-Xingrenaspis* de la région du Cachemire est déjà connue, la découverte actuelle d'association similaire dans le Spiti

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ORIGINAL PAPER

Assessment of groundwater depletion–induced land subsidence and characterisation of damaging cracks on houses: a case study in Mohali-Chandigarh area, India

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Abstract

The present study identified groundwater depletion–induced land subsidence by spaceborne differential interferometric SAR (DInSAR) technique and assessed the damaging impacts of land subsidence by characterising the cracks on houses in Mohali-Chandigarh area of India. First, we identified groundwater depletion hot spots using pre-monsoon and post-monsoon groundwater-level (GWL) data of Central Ground Water Board (CGWB), India, for the period of 2005–2018. Both conventional and advanced DInSAR techniques were used to identify temporally consistent subsiding areas and measure precise rates of subsidence in and around groundwater depletion hot spots. We studied the damaging impacts of land surface deformation by characterising the damaging cracks on houses in affected areas. Groundwater depletion and resulting aquifer-system compaction increase effective stress on confining clay layer which leads to stress build-up at the soil-structure interface and causes damaging cracks on houses. A variety of damaging cracks on houses were observed at the affected areas such as Sohana, Landran, Kharar and Kurali localities. We attempted to characterise the damaging cracks on the basis of shape, size, orientation, surface morphology and texture of the cracks; sense of ground movement; and nature of stress build-up at the interface. We identified tensional cracks, compressional cracks and shear cracks with diverse orientations and separation widths. Finally, a comparative assessment of groundwater depletion, land subsidence and damaging impacts on houses has been made. Using DInSAR technique, we identified land subsidence in and around the groundwater depletion areas in Sohana and Landran (both in Mohali City area), Kharar and Kurali (in Mohali district outside Mohali City area) and Sectors 27–28 in Chandigarh with radar line-of-sight subsidence rates of ~6–7.5 cm/year, ~5.5–6.5 cm/year, and ~ 4 cm/year respectively. We observed that the houses in and around Landran appears to be worst affected followed by Kharar, Sohana and Kurali. From this study, it appears that the type of construction of the houses, e.g. prevalence of masonry and reinforced masonry structures, is primarily responsible for the worst damaging impacts of the houses in Landran and Kurali areas besides the magnitude of land subsidence.

Keywords Groundwater depletion · Land subsidence · DInSAR · PSInSAR · Damaging cracks on houses

Introduction

Different parts of the world such as South and Central Asia, Australia, North America, North Africa, North China, Middle East and other localised areas are affected by extensive groundwater depletion (Konikow and Kendy 2005). The main reason for groundwater depletion is over-extraction of groundwater for irrigation. Climate change in terms of irregular rainfall pattern and significant reduction in the number of rainy days during monsoon potentially exacerbate groundwater depletion in some regions. The impacts on groundwater resources are more evident in agriculture-dominated regions of India, China and the USA (Aeschbach-Hertig and Gleeson

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सुरक्षा की दृष्टि से उत्तराखण्ड़ का महत्व

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उत्तराखण्ड़ राज्य भारत के उत्तरी सीमा पर स्थित एक पर्वतीय राज्य है। इसका अधिकांश भाग हिमालय पर्वत के तीनों श्रृंखलाओं से घिरा हुआ है जिसमें महान हिमालय, मध्य हिमालय एवं शिवालिक श्रेणियाँ विद्यमान हैं। हिमालय पर्वत जो प्राचीन काल से भारत का प्रहरी माना गया। ऐतिहासिक दृष्टि से विचार करके देखा जाए तो हिमालयी क्षेत्र सुरक्षा के लिहाज से अति महत्वपूर्ण स्थान रखता हैं इसको पार कर पाना आसान नहीं है इसके अलावा हिमालय पर्वत के विशाल आकृति व महानता के कारण ही भारत को मध्य एशिया व यूरोप के देशों के प्रभाव से मुक्त रखा है। इस अवरोध के कारण ही यह अपनी सभ्यता व संस्कृति को जन्म दिया व विश्व में अलग पहचान बनायी है। उत्तराखण्ड़ को विश्व भर में देव भूमि के नाम से जाना जाता है। इसका कारण यहाँ हिन्दुओं के प्रसिद्व तीर्थ एवं ऋषिमुनियों की तपस्थलियाँ विद्यमान हैं। जिसका प्रमाण वैदिक काल के ग्रन्थो में मिलता है जिसमें वेद पुराण, रामायण, महाभारत आदि प्रमुख साहित्य इस क्षेत्र की प्रमाणिकता देते हैं। उत्तराखण्ड़ का उदय बड़े संघर्षो व आन्दोलनों के पश्चात् 9 नवम्बर 2000 को भारत के 27वें राज्य के रुप में अस्तित्व में आया उत्तराखण्ड़ के उदय का प्रमुख कारण यह था कि उत्तर प्रदेश में स्थित यह भू-भाग विकास में पिछड़ रहा था पिछड़ेपन व विकास की धीमी गति को विकास के मार्ग पर लाने के लिये उत्तर प्रदेश से पृथक होकर इस पर्वतीय राज्य का उदय हुआ। पहले इसे उत्तरांचल के नाम से जाना जाता था। 1 जनवरी 2007 में जनता की भावना का सम्मान करते हुए इसका नाम उंत्तराखण्ड कर दिया गया।

उत्तराखण्ड राज्य की स्थिति एवं विस्तार उत्तर पूर्व के मध्य में है। यह $28^0 43''$ से $31^0 27''$ उत्तरी अक्षांश तथा $77^0 34''$ से $81^0 02''$ पूर्वी देशान्तर के मध्य में स्थित है। इसका क्षेत्रफल 53484 वर्ग कि.मी. है। इसके पूर्व में नेपाल, उत्तर में हिमालय पार तिब्बत (चीन) पश्चिम में हिमाचल प्रदेश व हरियाणा तथा दक्षिण में उत्तर प्रदेश स्थित है। प्राकृतिक सीमा बनाने का कार्य उत्तर में तिब्बत हिमालय पश्चिम में टोंस नदी, पूर्व में काली नदी दक्षिण पश्चिम में शिवालिक श्रेणियाँ अलग करती हैं। प्रशासनिक दृष्टि से इसे दो मण्डलों में बाटा गया है गढ़वाल मण्डल एवं कुमाँऊ मण्डल। गढ़वाल मण्डल में 7 जिले उत्तरकाशी, चमोली, रुद्रप्रयाग, पौड़ी गढ़वाल, टिहरी गढ़वाल देहरादून, हरिद्वार एवं कुमाँऊ मण्डल में 6 जिले नैनीताल, पिथौरागढ़, चम्पावत, अल्मोड़ा, बागेश्वर, ऊधम सिंह नगर स्थित हैं। उत्तराखण्ड़ का आकार आयताकार है इसकी चौड़ाई (उत्तर से दक्षिण) 390 कि.मी. तथा लम्बाई (पूर्व से पश्चिम) 358 कि.मी. है। उच्च पर्वतीय भाग एवं अल्पविकसित साधनों के कारण यहाँ जीवन बड़ा ही संघर्ष भरा है अर्थत पहाड़ में पहाड़ भरा जीवन जिससे यहाँ की जीवन शैली बड़ी ही जटिल है।

भारतीय सुरक्षा में उत्तराखण्ड राज्य का विशेष स्थान है। उत्तराखण्ड़ राज्य की सीमा रेखा चीन व नेपाल से लगी हुई है जो सुरक्षा दृष्टि से अति महत्वपूर्ण है। उत्तराखण्ड के सीमावर्ती जिले जिनमें उत्तरकाशी, चमोली, पिथौराढ़, चम्पावत एवं उधमसिंह नगर जो चीन एवं नेपाल की सीमा से लगे हुये हैं जो सामरिक दृष्टि से अत्यन्त महत्वपूर्ण है जो घुसपैठ कर हमारी भूमि पर अतिक्रमण करके सीमा विवाद को बढ़ावा दे रहा है साथ ही सीमा विवाद को सुलझाने के बजाय उसे उलझाने में अधिक रूचि दिखा रहा है। चीन न तो सीमा विवाद के लिये अपना स्पष्ट रवैया अपना रहा है और ना ही किसी बातचीत के लिये तैयार है चीन भारत को इस सीमा विवाद में उलझाये रखना चाहता हैं जो उसकी कूटनीतिक चाल है। जिसका अंदाजा चीन की विस्तार वादी नीति से लगाया जा सकता है।[1]

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भारतीय युवकों का सशस्त्र सेनाओं के प्रति गिरता रूझान

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सारांश –

सशस्त्र सेनायें किसी भी राष्ट्र की सुरक्षा और शक्ति का प्रतीक होती है, सैन्य शक्ति किसी देश की सुरक्षा का प्रमुख आधार होती है क्योंकि इसके अभाव में किसी क्षेत्र, प्रदेश सामरिक प्रतिष्ठान एवं जनमानस की रक्षा नहीं की जा सकती है। अन्तर्राष्ट्रीय स्तर पर किसी राष्ट्र को शक्तिशाली या कमजोर प्रदर्शित करने वाले तत्वों में उस राष्ट्र की सैन्य क्षमता की भूमिका भी उतनी ही महत्वपूर्ण है जितने की आर्थिक और राजनीतिक तत्व। अतः सशस्त्र सेनाओं का गुणात्मक, संख्यात्मक, तकनीकी आदी सभी तरह प्रकार की क्षमताओं से पूर्ण होना अत्यन्त आवश्यक है। भारतीय सेना की गिनती विश्व की विशालतम सेनाओं में की जाती है। वहीं वर्तमान समय में भारतीय सशस्त्र सेनायें लगभग 52,000 कार्मिकों, जिसमें से 11,000 अधिकारी वर्ग के पद है, की कमी से जूझ रही है। बदलते सामाजिक परिवेश, आर्थिक आवश्यकताओं, कार्यस्थल की दशाओं आदि का सीधा असर सेना के आकार पर पड़ रहा है। आज के युवाओं का रूझान सशस्त्र सेनाओं के प्रति कम हुआ है तो दूसरी ओर जिन्होंने सेना को चुना वे भी विभिन्न कारणों से समय से पूर्व ही सेवानिवृत्ति ले रहे है जो की एक गम्भीर चिंता का विषय है, यदि यहीं हालात रहे तो आने वाले दस वर्षों में भारतीय सेना की स्थिति सोचनीय हो सकती है। आज भारतीय सेना एक ओर तो सीमाओं पर शत्रुओं से जूझ रही है वहीं दूसरी ओर आंतरिक रूप से सैनिकों की कमी से जूझ रही है।

सांकेतिक शब्द : सशस्त्र बल, थल सेना, अधिकारियों की कमी, भारतीय जवान।

प्रस्तावना –

आज से ढ़ाई हजार वर्ष पूर्व आचार्य कौटिल्य ने राज्य के सप्तांग सिद्धान्तों में सेना (बल) को द्वितीय स्थान देकर किसी भी राष्ट्र या राज्य को सुरक्षा हेतु सेनाओं की अपरिहार्यता एवं महत्ता को प्रमाणित कर दिया। इसलिए आधुनिक युग में भी सेना की महत्ता को दृष्टिओझल नहीं किया जा सकता। राष्ट्र रक्षा एवं राष्ट्र प्रेम की भावना में विश्वास रखने का एक अलग महत्व होता है। इसी महत्व के कारण सेना में जाना एक गौरवपूर्ण बात मानी जाती थी। इसी परम्परा से अपने शौर्य और पराक्रम का झण्डा बुलन्द करने वाली दुनिया की चार सर्वोत्तम सेनाओं में एक मानी जाने वाली भरतीय सेना आज भी भारतीय जन में सर्वाधिक आदर का पात्र मानी जाती है। इसीलिए इस सेना को देखकर अमेरिका के राष्ट्रपति ने कहा था कि– "मेरी तकनीकी और भारतीय सेना अगर एक हो जाए तो मैं पूरे विश्व पर राज कर सकता हूँ।" आजादी के पूर्व भी अंग्रेजी राज वाली सेना की भूमिका, उसकी मारक क्षमता तथा कई अन्य मामलों में बहुत बदलाव आया है। दुनिया भर में हथियारों की होड़ बढ़ रही है तथा सेनाओं को मजबूत बनाया जा रहा है। भारतीय सेना भी इन बदलावों के मध्यनजर नई युद्ध प्रणाली तथा साजो-सामान से लैस तो हो रही हैं, बड़े पैमाने पर आधुनिकीकरण के साथ स्वदेशीकरण में भी सेना अग्रणी है। भारत एक विशाल देश है जिसके पास न केवल लम्बी-चौड़ी सरहदें है, बल्कि देश में भीतरी खतरों की भरमार भी है। पड़ौसी राष्ट्रों में बलशाली चीन तथा हथियारों की अन्धी होड़ में शामिल पाकिस्तान अब भी पाकिस्तान के लिए खतरा बना हुआ है। इन गम्भीर परिस्थितियों में भारतीय सेना के सामने कई चुनौतियाँ आ रही हैं। सैन्य इतिहास में पहली बार यह स्थिति आई है कि सेना को नये सैन्य अधिकारियों की कमी का सामना करना पड़ रहा है। आने वाले दिनों में यह कमी सेना को अत्यधिक प्रभावित करेगी, सेना के कई

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पाँव रखता हुआ, धीरे–धीरे। मुफ्त में मजदूरी देनी हो तो और बात है।' अ

लेकिन रेणु अपने ऐसे पात्रों का चरित्रांकन एकांगी नहीं करते। रेणु के सिरचन में कुछ ऐसा भी है जिसके कारण वह विशेष है। रेणु लिखते हैं, 'सिरचन जाति का कारीगर है। मैंने घंटों बैठकर उसके काम करने के ढंग को देखा है। एक–एक मोथी और पटेर को हाथ में लेकर बड़े जतन से उसकी कुच्ची बनाता। फिर, कुच्चियों को रँगने से लेकर सुतली सुलझाने में पूरा दिन समाप्त।कृकाम करते समय उसकी तन्मयता में जरा भी बाधा पड़ी कि गेहुँवन साँप की तरह फुफकार उठता—''फिर किसी दूसरे से करवा लीजिए काम! सिरचन मुँहजोर है, कामचोर नहीं।'' सिरचन मानवता से भी ओत–प्रोत है। मानू के लिए बड़े जतन से बनायी गयी चीजों को ट्रेन में पहुँचा आता है और बदले में कुछ भी स्वीकार नहीं करता।

उपरोक्त विमर्श के आधार पर हम कह सकते हैं कि रेणु के पात्र विशेष हैं और सम्पूर्ण मानवीय विशेषताओं को अपने अंदर वास्तविक रूप में संजोये हुए हैं।

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सैनिकों में बढ़ती आत्महत्या व भ्रातृवध की प्रवृत्ति : एक विश्लेषण

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सारांश –

भारतीय सेना जिसकी गणना विष्व की सर्वश्रेश्ठ सेनाओं में की जाती है। अपने साहस और वीरता के कारण ही भारतीय सैनिकों को स्वतन्त्रता पूर्व अंग्रेजी सरकार ने अपना सर्वोच्च सम्मान 'विक्टोरिया क्रॉस' प्रदान किये। लेकिन आज वहीं भारतीय सेना राजनीतिक उपेक्षा व कुछ आंतरिक कारणों से कई गंभीर समस्याओं से घिरी हुई है। आज भारतीय सैनिक एक ओर अलगाववाद, आतंकवाद से जूझ रहे है तो दूसरी ओर सेना में अवसाद व तनाव के चलते बढ़ती आत्महत्या की घटनाओं से ग्रसित है। प्रस्तुत शोध–पत्र में भारतीय थल सेना की इन्हीं समस्याओं पर प्रकाश डालने का प्रयास किया गया है। आज प्रत्येक व्यक्ति यह सोचने के लिए मजबूर हो गया है कि आखिर सेना में कौन सी ऐसी समस्या है जो कि इन घटनाओं के लिए जिम्मेदार है। बढ़ती आत्महत्या की घटनाओं के कारण आज भारतीय जनमानस अपने बच्चों को सेना में भेजने से पहले इस पर सोचने के लिए बाध्य हो गया है जिसका सीधा असर भारतीय सेना के आकार पर पड़ रहा है।

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वित्तविना शूद्र खचले, इतके अनर्थ एका अविद्येने केले

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भारतीय सेना में महिलाओं की यौद्धिक भूमिका : एक विश्लेषण

अनिल कुमार मीना
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सारांश —

वर्तमान वैश्विक परिप्रेक्ष्य में देखे तो विश्व के सभी देश महिलाओं को सेना में जाने की छूट नहीं देते, कुछ देशों ने अब महिलाओं के प्रतिबन्धों को हटाकर सेना में पुरूषों के समान भर्ती के दरवाजे खोले है लेकिन यौद्धिक कार्यवाहियों में जाने की खुली छूट नहीं दी गई है। वर्तमान में अमेरिकी सेना में सैन्य संख्या का लगभग पन्द्रह प्रतिशत महिलाएं है लेकिन अमेरिकी समाज अभी भी महिलाओं को कानूनी तौर पर यौद्धिक कार्यवाहियों में शामिल करने के पूर्णत: पक्ष में नहीं है। जो महिलाएं यौद्धिक कार्यवाहियों में शामिल हुई है उन्हें विशेष चुनौतियों का सामना करना पड़ा है जैसे— लैंगिक मुद्दे : गर्भधारण, उत्पीड़न, अभद्रता, बलात्कार और सहमती से संबंध इनके अलावा हत्या और आत्महत्या के मामले भी सामने आए है। एक तथ्य यह भी है कि यदि सशस्त्र बलों में महिलाओं की संख्या तो बढ़ रही है लेकिन अधिकतर राष्ट्र महिलाओं को यौद्धिक कार्यवाहियों में सीधे तौर पर भेजने को टालते ही है। विष्व के सभी देश महिलाओं को सेना में जाने की छूट नहीं देते, कुछ देशों ने अब महिलाओं के प्रतिबन्धों को हटाकर सेना में पुरूषों के समान भर्ती के दरवाजे खोले है लेकिन अभी भी यौद्धिक कार्यवाहियों के तीसरे हिस्से अर्थात जमीनी जंग में दुश्मन के सामने खुलकर लड़ने की कार्यवाहियों में शामिल नहीं किया गया। प्रस्तुत शोध पत्र में सषस्त्र बलों में महिलाओं की दशा और दिषा पर मंथन किया गया है।

कुंजी शब्द —सशस्त्र बल, महिलाएँ, सेना में महिलाएँ, महिला लड़ाकू बल, फ्रंट लाइन।

प्रस्तावना—

वैसे देखा जाए तो आज महिलाओं ने प्रत्येक क्षेत्र में जहां पुरूषों का एकाधिकार समझा ज़ाता था अपने कदम बढ़ाये है और सफलतापूर्वक अपनी जिम्मेदारियों को निभा रही है, और पुरूष सहयोगी भी उनके साथ है लेकिन जब प्रश्न 'सैन्यसेवा' का आता है तो कई प्रकार के तर्क सामने आते है, कुछ का कहना है कि स्त्री और पुरूषों में कोई भेदभाव नहीं है अर्थात लैंगिक समानता के नाम पर यह कहा जाता है कि स्त्रियां भी पुरूषों के समान कोई भी कार्य कर सकती है अब इनकी मांग है कि पुरूष अधिकारियों की तरह हमें भी यौद्धिक कार्यवाहियों में शामिल किया जाए। दूसरी ओर सेनाधिकारियों को इस बात से हमेशा हिचक होती रही है कि अगर विषम परिस्थितियों में जंग के दौरान महिला सैनिक/अधिकारी दुश्मन की गिरफ्त में आ जाती हैं, तो उन्हें जो प्रताड़ना सहनी पड़ेगी, वह देश के लिए शर्मनाक होगी। तो महिलाओं का तर्क आता है कि, भारतीय शास्त्रों में नारी को शक्ति के रूप में असुरों का संहार करते बताया गया है। भारतीय प्राच्य इतिहास नारी की त्याग—तपस्या की गाथाओं से भरा पड़ा है। वैदिक युग में महिलाएं भी युद्ध में भाग लेती थीं अर्थात महिलाओं ने न केवल शास्त्रों से, अपितु शस्त्रों का वरण कर राष्ट्र की एकता और संप्रभुता की रक्षा भी की इस सन्दर्भ में यदि इतिहास के पन्नों को पलटा जाए तो प्राचीन भारतीय इतिहास ऐसे किस्सों से भरा पड़ा है। तो ऐसे में प्रश्न उठता है कि जब प्राचीन कालीन युद्धों में महिलाओं ने महत्वपूर्ण भूमिकाएँ अदा की है तो आज की इक्कीसवी सदी में क्यों महिलाओं को ऐसी भूमिकाओं

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भारतीय थल सेना के जवानों में तनाव का विश्लेषण

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सारांश

भारतीय सेना जिसकी गणना विश्व की सर्वश्रेष्ठ सेनाओं में की जाती है। अपने साहस और वीरता के कारण ही भारतीय सैनिकों को स्वतन्त्रता पूर्व अंग्रेजी सरकार ने अपना सर्वोच्च सम्मान 'विक्टोरिया क्रॉस' प्रदान किये। लेकिन आज वही भारतीय सेना राजनीतिक उपेक्षा व कुछ आंतरिक कारणों से कई गंभीर समस्याओं से घिरी हुई है। आज भारतीय सैनिक एक ओर अलगाववाद आतंकवाद से जूझ रहे है तो दूसरी ओर सेना में अवसाद व तनाव के चलते बढ़ती आत्महत्या की घटनाओं से ग्रसित है। प्रस्तुत शोध-पत्र में भारतीय थल सेना की इन्हीं समस्याओं पर प्रकाश डालने का प्रयास किया गया है। आज प्रत्येक व्यक्ति यह सोचने के लिए मजबूर हो गया है कि आखिर सेना में कौन सी ऐसी समस्या है जो कि इन घटनाओं के लिए जिम्मेदार है।

कुंजी शब्द –सेना में आत्महत्या, भ्रातृवध, तनाव, सैन्य समस्याएँ, अधिकारियों की कमी, कम वेतन।

प्रस्तावना

अत्यन्त दुखद एवं विचारणीय तथ्य है कि आज वही बहादुरी और वीरताओं के किस्सों से भरी भारतीय सेना एक ओर आतंकवाद, अलगांववाद और इंसर्जेंसी जैसी विकट समस्याओं से जूझ रही है, तो दूसरी ओर भारतीय सेना बढ़ती आत्महत्या की घटनाओं व अधिकारियों की कमी का दंश भी झेल रही है ये ऐसी समस्याएँ है जो आतंकवाद और अलगाववाद से भी कई गुना भयानक है, क्योंकि न तो इसमें शत्रु का पहले से पता चल पाता है और न ही समस्या का। यदि विगत कुछ वर्षों से देखा जाए तो पता चलता है कि जितने सैनिक आतंकवाद और अलगाववाद के शिकार हुए उससे कहीं अधिक इस अवधि में या तो खुद या फिर अपने साथी की गोली का शिकार हुए। सेना में बढ़ती आत्महत्या की इन

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पूर्वोत्तर के सीमान्त राज्यों के दर्रों का सामरिक महत्व

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सारांश :

भारत के पूर्वोत्तर में स्थित सीमान्त राज्य अरूणाचल प्रदेश, आसाम, नागालैंड, मणिपुर मिजोरम मेघालय, त्रिपुरा, सिक्किम आदि का अत्यधिक महत्व है। पूर्वोत्तर के सीमान्त राज्य जन-आंदोलनों, जन्नजातिय विद्रोहो, सीमान्त मुद्दों की वजह से अक्सर चर्चा में रहते है। उपरोक्त के अतिरिक्त पूर्वोत्तर के सीमान्त राज्यों में कई सामरिक महत्व के दर्रे है, जो भू-स्त्रॉतेजिक दृष्टि से भी महत्वपूर्ण है। पूर्वोत्तर राज्यों की सीमा पर स्थित पड़ोसी चीन, नेपाल, भूटान, म्यांमार, बांग्लादेश आदि देशों की सीमाएं मिलती है जो इस क्षेत्र को और अधिक संवेदनशील बना देती है। इनमें सबसे ज्यादा खतरा अरूणाचल सेक्टर में चीनी विस्तारवादी नीति से है। उल्लेखनीय है कि प्राचीन काल से भारत के सीमान्त पर्वतीय राज्यों के दरो से पड़ोसी देशों के साथ व्यापार होता था लेकिन अब शत्रु राष्ट्र इन दर्रो का इस्तेमाल सैनिक संक्रियाओं हेतु भी कर सकते है यही बात इन दर्रों के भू-स्त्रॉतेजिक महत्व को बढ़ देती है।

की-वर्ड : पूर्वोत्तर, दर्रे, सामरिक महत्व, भू-स्त्रॉतेजिक।

पूर्वोत्तर के सीमान्त राज्यों में अरूणाचल प्रदेश, मणिपुर, मेघालय, मिजोरम, नागालैण्ड, त्रिपुरा, असम और सिक्किम राज्य आते है। जो 2,62,179 कि.मी. क्षेत्रफल में फैले हुये हैं, जो देश के कुल क्षेत्रफल का 8 प्रतिशत है। इन सीमान्त राज्यों का सामरिक महत्व का अनुमान इस तथ्य से लगाया जा सकता है कि एक लम्बी अन्तर्राष्ट्रीय सीमा और एक संकरी पट्टी जिसे आमतौर पर सिलीगुड़ी गलियारे (चिकन नेक) के नाम से जाना जाता है के द्वारा शेष भारत से जुड़ा हुआ है। इस सिलीगुड़ी गलियारे (चिकन नेक) की चौड़ाई 22 कि.मी. है। क्योंकि यह सीमान्त क्षेत्र पड़ोसी देशों के साथ 5430 कि.मी. कि.मी. लम्बी अन्तर्राष्ट्रीय सीमा साझा करता है जो राष्ट्रीय एवं अन्तर्राष्ट्रीय सीमा की 99 प्रतिशत है। इन सीमान्त राज्यों के उत्तर में चीन जैसे विस्तारवादी देश की सीमा अरूणाचल प्रदेश और सिक्किम से 1300 कि.मी. लगती है।

बांग्लादेश भारत से तीन तरफ से घिरा हुआ है जो रणनीतिक रूप से पूर्वोत्तर राज्यों के लिए महत्वपूर्ण है, 1880 कि.मी. लम्बी असम, मेघालय, मिजोरम, व त्रिपुरा की सीमा रेखा बांग्लादेश से लगती है। वहीं सिक्किम नेपाल से 97 कि.मी. लम्बी सीमा साझा करता है। म्यांमार, अरूणाचल प्रदेश, नागालैण्ड, मिजोरम और मणिपुर से

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LOOK EAST-ACT EAST DIMENSION OF FOREIGN POLICY AND IMPLICATIONS FOR NORTH-EAST

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The Look East policy of India is not just a contemporary effort but an attempt to resurr
cultural and trade interactions with South East Asian countries. Angkor Vat in Cambod
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levels of rulers but more significantly at the level of people and societies. When Cholas took
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goods and people but also creative ideas in arts and architecture. In that sense, India was
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Historical Background

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The Kalingas had sought trade with the East about 2000 years ago. Rajendra Chola's ef
are well documented to forge cultural links with these countries[1]. The Chola Empire had sp
from India to many countries in Southeast Asia. The effects of their cultural and architec
contributions in these countries are visible to this day. The Chola Empire may perhaps be see
the first movement in favor of the evolution of the India's Look East-Act East policy. It is r

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Shrinkhla Ek Shodhparak Vaicharik Patrika

आतंकवाद से प्रभावित होते भारत–पाकिस्तान संबंध

कमलेश चन्द्र पाण्डेय
अतिथि शिक्षक,
रक्षा एवं स्त्रॉतेजिक अध्ययन
विभाग, बिडला परिसर,
हे0नं0ब0ग0केन्द्रीय
विश्वविद्यालय,
श्रीनगर गढवाल, उत्तराखण्ड,
भारत

राकेश चन्द्र सिंह कुँवर
एसोसिएट प्रोफेसर एवं
विभागाध्यक्ष,
रक्षा एवं स्त्रॉतेजिक अध्ययन
विभाग, बिडला परिसर,
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विश्वविद्यालय,
श्रीनगर गढ़वाल, उत्तराखण्ड
भारत

सारांश

भारत व पाकिस्तान दक्षिण एशिया के दो ऐसे देश हैं, जिनके सम्बन्ध उनके जन्म से ही तनावपूर्ण रहे हैं। तनाव के बीच वार्ताओं का सिलसिला अधिक समय तक नहीं चल पाया।कश्मीर समस्या तथा अन्य मुद्दों को लेकर दोनों के मध्य 1947, 1965, 1971 तथा 1999 में चार बार बड़े सैनिक संघर्ष भी हो चुके हैं। इन सैनिक संघर्षों का परिणाम कुछ भी रहा हो, लेकिन इनका संदेश यह अवश्य रहा है कि पाकिस्तान भारत के साथ सीधे सैनिक संघर्ष में विजय हासिल नहीं कर सकता है। अतः पाकिस्तान ने भारत के साथ सैनिक समानता हासिल करने के लिए भारत विरोधी देशों के साथ सैनिक गठजोड़ के साथ–साथ आण्विक शस्त्रों के विकास तथा आतंकवाद को बढावा देने जैसे अन्य साधन भी अपनाता रहा है। भारत पाक संबंधों में बढ़ते तनाव के लिए निश्चय ही पाकिस्तान के आंतरिक हालात उत्तरदायी रहे हैं। पाकिस्तान में फौज और नागरिक सरकार के बीच संबंध इसका सिर्फ एक पहलू है। पाकिस्तान पर चाहे सैनिक तानाशाह का शासन रहा हो या लोकतांत्रिक सरकार का शासन उनका व्यवहार नही बदलेगा। भारत ने पाकिस्तान समर्थित आतंकवाद का मुद्दा संयुक्त राष्ट्र संघ तथा अन्य वैश्विक मंचों पर भी उठाया है। इस मुद्दे पर भारत को काफी सफलता मिली है क्योंकि पाकिस्तान आतंकवाद के कारण वैश्विक पटल पर अलग–थलग होता जा रहा है। भारत अपने पड़ोसियों के साथ आपसी समझ, क्षेत्रीय शांति और स्थिरता को प्रोत्साहित करने के दृष्टि से सक्रिय और सहयोगी संबंधों पर जोर देता रहा है। सिर्फ भारत विरोधी दृष्टिकोण ही पाकिस्तान की राजनीतिक स्थिरता और समर्थन का आधार है, जबकि एक लोकतांत्रिक एवं समृद्धशाली पाकिस्तान ही भारत के हित में है। भारत इस नीति का सदैव समर्थक रहा है कि पाकिस्तान में स्वरथ लोकतांत्रिक प्रणाली एवं राजनीतिक स्थिरता की स्थापना बनी रहे। और यदि पाकिस्तान की सरकार चाहे तो यह लोकतांत्रिक हित में आतंकवाद को समाप्त करने के लिए दृढ़ इच्छाशक्ति के बल पर कोई ठोस कदम उठाए।

मुख्य शब्द : संबंध, संघर्ष, आतंकवाद, लोकतंत्र।

प्रस्तावना

ब्रिटिश उपनिवेशवाद की समाप्ति के पश्चात् एशिया महाद्वीप में एक नए संघर्ष की शुरूआत हुई जिसके परिणामस्वरूप इस क्षेत्र से शान्ति शब्द का लोप ही हो गया। यह संघर्ष था दक्षिण एशिया के दो पड़ोसी देशों का संघर्ष के नाम से जाना जाता है। भारत विभाजन के बाद से ही विभाजन के समय की घृणा और अविश्वास ने दोनों देशों को आज तक युद्ध की तैयारी में लगाए रखा है।[1] अगस्त 1947 में दो टुकड़ो में भारत का विभाजन करके भारत और पाकिस्तान नाम के राज्यों का निर्माण किया गया। जिसमें पाकिस्तान का जन्म साम्प्रदायिक आधार पर हुआ था। भारतीय मुस्लिम लीग द्वारा दो राष्ट्रों के सिद्धात का प्रतिपादन करते हुए भारतीय मुसलमानों के लिए एक पृथक राज्य की मांग रखी गई।[2] भारत व पाकिस्तान दक्षिण एशिया के दो ऐसे देश हैं, जिनके सम्बन्ध उनके जन्म से ही तनावपूर्ण रहे है। तनाव के बीच वार्ताओं का सिलसिला अधिक समय तक नहीं चल पाया। कश्मीर समस्या तथा अन्य मुद्दों को लेकर दोनों के मध्य 1947, 1965, 1971 तथा 1999 में चार बार बड़े सैनिक संघर्ष भी हो चुके हैं। इन सैनिक संघर्षों का परिणाम कुछ भी रहा हो, लेकिन इनका संदेश यह अवश्य रहा है कि पाकिस्तान भारत के साथ सीधे सैनिक संघर्ष में विजय हासिल नहीं कर सकता है। अतः पाकिस्तान ने भारत के साथ सैनिक समानता हासिल करने के लिए भारत विरोधी देशों के साथ सैनिक गठजोड़ के साथ–साथ आण्विक शस्त्रों के विकास तथा आतंकवाद को बढ़ावा देने जैसे अन्य साधन भी अपनाता रहा है। 1971 के युद्ध के बाद दोनों देशों के बीच 1972 में ऐतिहासिक शिमला समझौता हुआ जिसमें अन्य बातों के अतिरिक्त इस बात पर सहमति बनी कि दोनों देश अपने विवादों को द्विपक्षीय बातचीत के

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मणिपुर में उग्रवाद एवं छोटे हथियारों का प्रसार

Extremism and Small Arms Proliferation In Manipur

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कमलेश चन्द्र पाण्डेय
शोधार्थी
पोस्ट डॉक्टोरल फैलो,
भारतीय सामाजिक विज्ञान
अनुसंधान परिषद,
नई दिल्ली, भारत

आर0 सी0 एस0 कुँवर
शोध निर्देशक
प्रोफेसर एवं विभागाध्यक्ष,
रक्षा, स्ट्रेटजिक एवं भू
राजनीतिक अध्ययन विभाग,
बिड़ला परिसर,
ई0एम0एम0कें0 केन्द्रीय
विश्वविद्यालय, श्रीनगर
गढ़वाल, उत्तराखण्ड, भारत

सारांश

21 जनवरी 1972 को मणिपुर पूर्ण राज्य के रूप में अस्तित्व में आया। वर्तमान में मणिपुर में 16 जिले हैं। भौगोलिक दृष्टि से मणिपुर के उत्तर में नागालैंड, उत्तर-पूर्व में असम, दक्षिण में मिजोरम, पूर्व में म्यांमार और पश्चिम में असम का कछार जिला आता है। सम्पूर्ण उत्तर-पूर्व भारत सात राज्यों असम, अरुणाचल प्रदेश, मणिपुर, मेघालय, मिजोरम, नागालैंड, त्रिपुरा भारत के 7.6 प्रतिशत भूमि क्षेत्र और भारत की कुल आबादी का 3.6 प्रतिशत शामिल है। सन् 1940 के दशक के उत्तरार्ध से सशस्त्र संघर्ष का सामना कर रहा है। स्वतंत्रता के लिए और उत्तर पूर्व में नए राज्यों के लिए विभिन्न जातीय समूहों द्वारा हिंसक और मुखर मांगें पिछले पांच दशकों में हुई हैं। मणिपुर राज्य में बांग्लादेश से आए घुसपैठियों की वजह से अनेक समस्याएं उत्पन्न हुई। मणिपुर में आदिवासी नगा–कूकी तथा मैती व बीच काफी पुराने विवाद हैं। यहाँ उग्रवाद जातीय मुद्दे, आपराधिक गतिविधियों और नशीले पदार्थ की समस्या भी गम्भीर है। उग्रवाद के कारण मणिपुर में छोटे हथियारों का प्रसार भी हुआ है। सन् 1978 में एन0बी0 शेखर, सुधीर और सुमंद नामक 3 युवकों के नेतृत्व में मणिपुर में हजारों युवक भर्तियों की कतारों में शामिल हुए थे। बाद में इन तीनों के बगावत की पलट से हट जाने के बाद भी मणिपुर में उग्रवाद की स्थितियां बनी रही। सेना और असम राइफल्स सहित अन्य सुरक्षा बल राज्य से उग्रवाद की समस्या को समाप्त करने के लिए पूर्ण प्रयास कर रहे हैं। गृह मंत्रालय द्वारा भ्रमित युवाओं और उग्रवादियों को, जो उग्रवाद में भटक गए हैं, उनके आत्मसमर्पण, सहयुन्मोत्तर तकनीकी योजना को कार्यान्वित किया जा रहा है।

Manipur became a full-fledged state on 21 January 1972. Currently, Manipur has 16 districts. Geographically, Nagaland comes to the north of Manipur, Assam in the north-east, Mizoram in the south, Myanmar in the east and Cachar district of Assam in the west. The entire North-East of India comprises seven states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura covering 7.6% of the land area of India and 3.6% of the total population of India. It has been facing armed conflict since the late 1940s. Violent and outspoken demands by various ethnic groups for independence and for new states in the North East have occurred over the past five decades. Many problems arose due to intruders from Bangladesh in the state of Manipur. There are longstanding disputes between the tribal Naga-Kuki and Mati in Manipur. Here, extremism, caste issues, criminal activities and narcotics problem are also serious. Extremism has also led to the proliferation of small arms in Manipur. Thousands of young men joined the queues in Manipur in 1978 under the leadership of 3 youths named NB Shekhar, Sudhir and Sumendra. Later, despite the withdrawal of the rebellion by these three, the conditions of insurgency remained in Manipur. The Army and other security forces, including the Assam Rifles, are making full efforts to eliminate insurgency from the state. The Ministry of Home Affairs is implementing the scheme of surrender, co-rehabilitation of disillusioned youths and militants who have wandered into extremism.

मुख्य शब्द : मणिपुर, उग्रवाद, हथियार, प्रसार।

Manipur, extremism, weapons, proliferation

प्रस्तावना

मणिपुर का शाब्दिक अर्थ 'मणि की धरती' या 'रत्नों की भूमि' है। मणिपुर में कई संस्कृतियों के लोग रहते हैं जैसे कुकी, नागा, पामल और मिजो,

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छोटे हथियारों का व्यापार एवं मानव सुरक्षा

डॉ कमलेश चन्द्र पाण्डेय
एवं आर0 सी0 एस0 यूनियर

यदि हम मानव जीवन का अध्ययन करें तो ज्ञात होगा कि उसने स्वयं के विकास के साथ-साथ मनुष्य की सुरक्षा में भी लघु और दीर्घ परिवर्तन हुए। मनुष्य को न केवल व्यक्तिगत अपितु सामूहिक सुरक्षा में भी अपनी सुरक्षा दृष्टिगत होने लगी। जहां तक राष्ट्र-राज्यों का सबध है, उनकी सुरक्षा आंतरिक एवं बाह्य दोनों प्रकार के खतरों से समाहित होती है। इन खतरों से निपटने के लिए पहले असैनिक उपायों का प्रयोग किया जाता है और जब असैनिक उपाय सफल प्रतीत नहीं होते तब सैनिक उपायों का सहारा लिया जाता है। अत: ऐसा प्रतीत होता है कि अस्त्र-शस्त्र मानव मात्र एवं राज्यों की सुरक्षा प्रक्रिया के महत्वपूर्ण घटक होते हैं। किंतु जब यही अस्त्र-शस्त्र वैधानिक एवं नियंत्रित व्यवस्था के अभाव में प्रवाहित एवं प्रसारित होने लगते हैं, तो उसी समाज की सुरक्षा के लिए एक समस्या उत्पन्न कर देते हैं, जिस समाज की सुरक्षा के लिए इनका आविष्कार एवं निर्माण किया गया होता है। इस प्रकार के अवैधानिक छोटे हथियार आज राष्ट्रीय एवं अन्तर्राष्ट्रीय शांति व सुरक्षा के लिए समस्या बन चुके है।[2]

छोटे हथियारों के प्रसार के कारण

छोटे एवं हल्के हथियारों का प्रसार निम्नलिखित कारणों से होता है–

1–बड़ी शक्तियों की आपसी प्रतिद्वंद्विता और विदेशी मुद्रा की प्राप्ति

2–राष्ट्रीय उत्पादन, आयात अथवा तकनीकी हस्तांतरण और राष्ट्रीय आय में वृद्धि

3–रोजगार के अवसरों में वृद्धि

4–राजनीतिक, सामाजिक एवं आर्थिक पृष्ठभूमि, तकनीकी शोध का बहाना

5–सीमा पार आतंकवाद

फलत: छोटे हथियारों के प्रसार से हिंसा में वृद्धि होती है। संगठित अपराधी गुट पनपते हैं, आंतरिक मामलों में हस्तक्षेप में वृद्धि होती है, अन्तर्राष्ट्रीय आतंकवाद एवं मादक पदार्थों की तस्करी को बढ़ावा मिलता है तथा सीमापार आवागमन में अधिक तेजी

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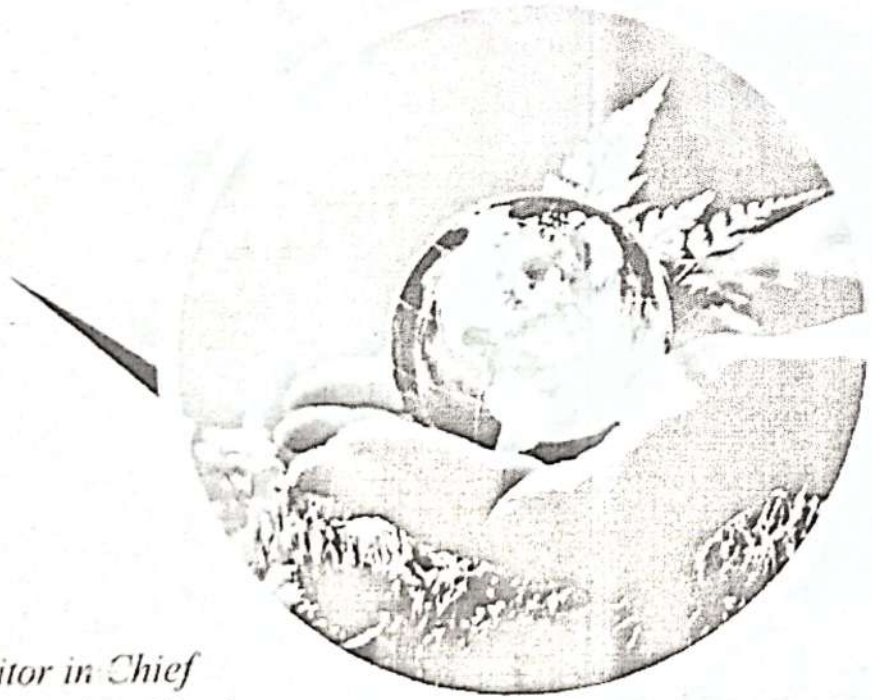

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छत्तीसगढ़ में नक्सलवाद: समस्या एवं समाधान

डॉ0 कमलेश [illegible] पाण्डेय*
प्रो0 आर0 सी0 एस0 कुँवर**

छत्तीसगढ़ राज्य का संक्षिप्त परिचय

छत्तीसगढ़ का पहले नाम दक्षिण कोशल था और इसका इतिहास 4 शताब्दी ईसवीं पुराना है। इसका पौराणिक इतिहास रामायण और महाभारत काल से जुड़ा है। हैहय राजवंश ने छत्तीसगढ़ पर 14वीं सदी के आसपास लगभग छः सदियों तक राज किया। मध्य युग में चालुक्य साम्राज्य ने खुद को बस्तर में स्थापित किया। अन्नमदेव नाम के पहले चालुक्य शासक थे, जिन्होंने सन् 1320 में बस्तर में राजवंश स्थापित किया। सन् 1741 में मराठों ने हैहय शासकों से यह राजवंश छीन लिया। मराठों ने राज्य जीतने के बाद वर्ष 1745 में रतनपुर घराने के अंतिम राजा रघुनाथ सिंह जी को क्षेत्र छोड़ने पर मजबूर किया। आखिरकार सन् 1758 में मराठों ने छत्तीसगढ़ पर विजय हासिल की और बिंबाजी भोंसले को शासक घोषित किया गया। बिंबाजी भोंसले के देहांत के बाद मराठों ने सूबा प्रणाली का पालन करना शुरु कर दिया। यह वो दौर था जब राव तरफ अशांति और कुशासन था। मराठा सेना ने तब बड़े पैमाने पर लूट पाट की थी।[1] मध्य प्रदेश पुनर्गठन विधेयक 1998 के द्वारा 1 नवंबर 2000 को स्थापित छत्तीसगढ़ राज्य का क्षेत्रफल 1,35,194 वर्ग कि0मी0 है। राज्य की जनसंख्या 2,55,45,198 है जिसमें 1,28,32,895 पुरुष व 1,27,12,303 महिलाएं हैं। जनसंख्या का घनत्व 189 प्रति वर्ग कि0मी0 है। मूलतः ग्रामीण प्रदेश छत्तीसगढ़ की 82.56 प्रतिशत जनसंख्या 19,658 गांवों में रहती है। छत्तीसगढ़ में 27 जिले हैं। आदिवासी बहुल बस्तर, रायगढ़ एवं सरगुजा जिलों में ग्रामीण जनसंख्या अधिक है। छत्तीसगढ़ राज्य की साक्षरता 71.04प्रतिशत है। यहाँ 81.45 प्रतिशत पुरुष व 60.59 प्रतिशत महिलाएं साक्षर हैं। इस राज्य की सीमाएं उड़ीसा, झारखंड, आंध्र प्रदेश, महाराष्ट्र और मध्य प्रदेश से लगती हैं। छत्तीसगढ़ राज्य की अर्थव्यवस्था कृषि प्रधान है। राज्य के 85 प्रतिशत लोगों की आजीविका कृषि से ही चलती है। यहां की भूमि उपजाऊ एवं कीमती खनिजों से भरी पड़ी है। छत्तीसगढ़ का 70 प्रतिशत राजस्व इस क्षेत्र से मिलता है। छत्तीसगढ़ वन संपदा के मामले में भी समृद्ध है क्योंकि 40 प्रतिशत हिस्सा वनों से आच्छादित है जिसमें से 36 प्रतिशत हिस्से में साल के वन हैं। इमारती लकड़ी का वार्षिक औसत उत्पादन 4.45 लाख घनमीटर है जिससे कुल वन राजस्व का 40 प्रतिशत प्राप्त होता है। बीड़ी उद्योग का आधार तेंदूपत्ता छत्तीसगढ़ के वनों की प्रमुख उपज है। यह भारत के कुल तेंदूपत्ता उत्पादन का 17 प्रतिशत होता है जो यहां के आदिवासियों की आजीविका का प्रमुख स्रोत है।[2] पीडब्ल्यूडी के तहत राज्य में सड़कों की कुल लंबाई 31,803 किलोमीटर है। राष्ट्रीय राजमार्गों की लंबाई 2,226 किलोमीटर, प्रांतीय राजमार्गों की लंबाई 5,240 किलोमीटर जिला सड़कों की लंबाई 10,539.80 किलोमीटर और ग्रामीण तथा अन्य सड़कों की लंबाई 13,798

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*आचार्यी पारस डाक्टोरल फैलो, भारतीय सामाजिक विज्ञान अनुसंधान परिषद्, नई दिल्ली भारत
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कौटिल्य का अर्थशास्त्र एवं सप्तांग सिद्धान्त का एक अध्ययन

आलोक कुमार
शोधार्थी, रक्षा, स्त्रॉतेजिक एवं भू-राजनीति अध्ययन विभाग,
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सारांश

कौटिल्य का अर्थशास्त्र जिसके जनक स्वयं कौटिल्य, चाणक्य या विष्णुगुप्त हैं जिन्होंने मौर्य वंश का शासक नियुक्त करने में अहम भूमिका निभाई है चाणक्य प्राचीन भारतीय इतिहास का कोई भी वर्णन चाहे व आर्थिक राजनैतिक सामाजिक हो या सैनिक कौटिल्य के अर्थशास्त्र के बिना अधूरा लगता है। कौटिल्य की नीतियां वर्तमान युग में भी अति प्रासंगिक हैं, इस लेख में कौटिल्य के अर्थशास्त्र में वर्णित सप्तांग सिद्धान्त का उल्लेख किया गया है। जिससे देश की कुशल कौटिल्य के अर्थशास्त्र की वर्तमान स्थिति अधिक अध्ययन में प्रासंगिकता-व्यवस्था संचालन की प्रक्रिया संभव हो पाती है। कौटिल्य के अर्थशास्त्र के माध्यम से हमें इस बात का बोध होता है कि देश के राजा के क्या कर्तव्य है, तथा प्रजातंत्र को कैसे सुंदर बना कर देश की जनता का कल्याण किया जा सकता है।

प्रस्तावना

अर्थशास्त्र समस्त सरकारी गतिविधियों का सबसे प्राचीन ग्रंथ है, इस ग्रंथ का वर्णन एक उत्कृष्ट रचना के रूप में किया गया है, जिसका संबंध विस्तृत विषयों से है। जैसे युद्ध कला और लोक प्रशासन के मुद्दे जिसमें राजनीतिक अर्थशास्त्र और प्रशासन शामिल हैं। अर्थशास्त्र द्वारा विकसित और स्थापित शासन और युद्ध के सिद्धांतों का अनुसरण भारत के अनेक शासकों ने किया जैसे अशोक और शिवाजी। जैसे कि अनेक विद्वानों द्वारा अवलोकन किया गया है, कौटिल्य की महिमा इसमें है कि उनके अर्थशास्त्र में सम्मिलित सिद्धांतों को उन्होंने इस योग्य बनाया है कि वे आज भी प्रासंगिक और उपयोगी हैं। इस लेख में कौटिल्य के अर्थशास्त्र एवं उसमें वर्णित सप्तांग सिद्धांतों पर ध्यान केंद्रित किया गया साथ ही समकालीन संदर्भ में उनकी प्रासंगिकता का परीक्षण किया जाएगा।

कौटिल्य का अर्थशास्त्र : एक परिचय

भारतीय प्रशासनिक इतिहास में कौटिल्य को एक महान् चिन्तक के रूप में प्रसिद्धि प्राप्त हैं। वस्तुतः प्राचीन भारतीय प्रशासन के साथ कौटिल्य का नाम पर्यायवाची के रूप में जुड़ा है। कौटिल्य ने ही "अर्थशास्त्र" की रचना की जो प्राचीन भारतीय राजनीतिक,

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भारत-नेपाल शान्ति एवं मैत्री सन्धि की वर्तमान समय में प्रासंगिकता

डॉ. सुबोध कुमार
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भारत और नेपाल के बीच दिनांक 31 जुलाई, सन् 1950 को शान्ति व मैत्री सन्धि सम्पन्न हुई। यह ऐतिहासिक, अति महत्वपूर्ण सन्धि दोनों देशों के पारस्परिक सद्भावना से जुड़ी हुई थी। इसने दोनों देशों के मध्य सम्बन्धों को आधारभूत ढाँचा प्रदान किया। यह सन्धि केवल राजनीतिक परिप्रेक्ष्य में ही नहीं की गयी थी, वरन् इसमें पारस्परिक प्राचीन सम्बन्धों की घनिष्ठता, सामाजिक, सांस्कृतिक, आर्थिक अन्तर्निर्भरता समाहित थी। आपसी सम्बन्धों को भविष्य में और प्रगाढ़ बनाने, एक दूसरे देश के हितों की रक्षा करने, नागरिकों के प्रति सम्मान, राष्ट्रीय व्यवहार समान सुरक्षा, व्यक्ति से व्यक्ति के सम्बन्धों तथा आर्थिक विकास की दृष्टि से यह सन्धि बहुत महत्वपूर्ण थी। 1950 की सन्धि की प्रस्तावना में कहा गया है कि- "भारत सरकार व नेपाल सरकार उन पुराने सम्बन्धों को स्वीकार करती है जो दोनों देशों के बीच सदियों से सुखान्त रूप में अवस्थित है।" इन सम्बन्धों को और मजबूत बनाने, विकसित करने के लिए शान्ति व मित्रता की सन्धि की जाती हैं।[1]

1950 की सन्धि को कार्यान्वित करने के पीछे दोनों राष्ट्रों के स्वार्थ निहित थे। जहाँ भारत-नेपाल से सन्धि कर अपनी उत्तरी सीमा की सुरक्षा को पुख्ता करना चाहता था, वहीं नेपाल भारत का सहयोग प्राप्त कर नेपाल के पूर्ण विकास में योगदान चाहता था। सन्धि में भारत ने नेपाल को उसके विकास में पूर्ण सहयोग देने का वचन दिया। नेपाल की तरफ से मोहन शमशेर ने कहा कि जब भी भारत को जरूरत होगी हम सहयोग करेगें और जब भी भारत की सुरक्षा खतरे में होगी हम मदद के लिऐ तैयार रहेंगे।[2] 31 जुलाई, 1950 को दोनों देशों के प्रतिनिधियों ने सन्धि पर हस्ताक्षर किये। यह सन्धि कतिपय संशोधनों के साथ आज भी अस्तित्व में है। यद्यपि यह सन्धि भारत-नेपाल सम्बन्धों में वर्तमान समय में असहमति का एक मुख्य मुद्दा है। नेपाल का कहना है कि 1950 की यह सन्धि तत्कालीन विश्व परिस्थितियों के सन्दर्भ में की गई थी, और आज परिस्थितियों में बहुत कुछ बदलाव हा चुका है। नेपाल की बात को मानते हुऐ भारत ने सन्धि में कई संशोधन किये तथा 1950 की सन्धि को कायम रखने के प्रयास किये, किन्तु नेपाल 1950 की सन्धि का कई बार उल्लंघन कर चुका है । वस्तुतः 1950 की सन्धि का अध्ययन दो भागों में विभक्त कर करेंगे।

(1) सन्धि के प्रति भारत का दृष्टिकोण व उसकी प्रासंगिकता
(2) सन्धि के प्रति नेपाल सरकार का दृष्टिकोण व उसकी प्रासंगिकता

(1) 1950 की सन्धि के प्रति भारत का दृष्टिकोण व उसकी प्रासंगिकता :

भारत का 1950 की सन्धि के प्रति सदैव एक जैसा व पारदर्शी दृष्टिकोण रहा है, तथा भारत के लिए आज भी सन्धि महत्वपूर्ण है। 1953 ई. को भारत द्वारा नेपाल को सन्धि के अनुरूप 10 लाख रुपये का अनुदान दिया गया साथ ही भारत ने जुलाई 1954 में नेपाल को आगामी चार वर्षो के लिए 50 लाख रुपये देना स्वीकार किया, यह अनुदान सड़क, सिंचाई, बिजली और पानी की परियोजनाओं के लिए दिया गया। इसके अतिरिक्त 1956 में नेपाल की प्रथम पंचवर्षीय योजना के लिए 10 करोड़ रुपये की सहायता दी।[3] 1950 की सन्धि के पीछे भारत की यह भावना थी कि भारत के लिए प्रतिरक्षा और प्रभाव की दृष्टि से नेपाल एक महत्वपूर्ण पड़ोसी राष्ट्र है। नेपाल के आर्थिक विकास और समुद्रतल के अभाव में आवश्यकता पूर्ति के लिए भारत को विशेष उत्तरदायित्व वहन करने हैं। नेपाल के चर्तुमुखी विकास और भारतीय सहायता प्राप्त परियोजनाओं की देख-रेख के लिए काठमाण्डू में सन् 1956 में एक सहायता मिशन

वर्ल्ड फोकस

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चीन-पाकिस्तान की सामरिक एवं आर्थिक युगलबंदी एवं भारतीय सुरक्षा

डॉ. भारती चौहान

आजादी के बाद हमसे अलग होकर स्वतंत्र रुप में अस्तीत्व में आया पाकिस्तान एक शत्रु राष्ट्र के रुप में हमारी पश्चिमी सीमा पर विराजमान हो गया। दूसरी तरफ हिन्दी–चीनी भाई–भाई का नारा देने वाला चीन भी अपनी विस्तारवादी नीति का जाल हमारी ओर फैलाने लगा। सन् 1962 में भारत–चीन युद्ध से हमारी उत्तरी सीमा पर चीन एक शत्रु राष्ट्र के रुप में स्थापित हो गया, और हमारी 15200 वर्ग किमी. की स्थल सीमा दो शत्रु राष्ट्रों से घिर गयी। इतना ही नहीं इन दोनों शत्रु राष्ट्रों के आपसी गठबंधन ने हमारी सीमा को और अधिक संवेदनशील बना दिया।

चीन-पाकिस्तान सम्बन्धों का आधार ?

भारत विरोधी गतिविधियां करके उसकी एकता अखण्डता को प्रभावित करना इनके सम्बन्धों का मुख्य आधार रहा है। अपनी आजादी के बाद से पाकिस्तान–भारत का घोर विरोधी बना हुआ है। अपने को पश्चिमी खेमे में शामिल करके भारत विरोधी रुख अपनाने लगा। सन् 1957 में ही पाकिस्तान के तत्कालीन प्रधानमंत्री सोहरावर्दी ने चीन के साथ अपने सम्बन्धों की घोषणा की कि "मैं चीन के साथ मित्रता पूर्ण सम्बन्ध चाहता हूँ। मैं इस विषय में अकेला नहीं हूँ। मुझे इस बात का पूर्ण विश्वास है कि जब संकट आयेगा तो चीन अपने मित्र की सहायता अवश्य करेगा।"[1] सुहरावर्दी की उस आशा ने उस समय रंग लाना शुरु किया जब सन् 1959 में भारत–चीन के मध्य सीमा के प्रश्नों को लेकर कटुता उत्पन्न होने लगी। सन् 1961 से पाकिस्तानी समाचार पत्रों ने यह प्रचार–प्रसार शुरु कर दिया था कि पाकिस्तान की ऐसे किसी प्रतिरक्षा संगठन में रुचि नहीं है जिसकी रचना चीन के विरुद्ध की गयी हो।[2] भारत पर चीनी आक्रमण के समय पाकिस्तान ने खुलकर चीन का समर्थन किया तथा भारत की स्थिति को कमजोर करने के लिए एवं चीन से मित्रता बढ़ाने के लिए पाक अधिकृत कश्मीर का 5180 वर्ग कि0मी0 क्षेत्र चीन को दे दिया। चीन ने इस क्षेत्र में कराकोरम राजमार्ग का निर्माण किया। 1300 कि0मी0 लम्बा यह हाई–वे कराकोरम पर्वत Üंखला से होकर गुजरता है। चीन–पाकिस्तान को यह मार्ग खुजरांव दर्रे के माध्यम से आपस में जोड़ता है। पाक अधिकृत कश्मीर के गिलगित–बाल्टिस्तान एवं चीन के शिननियांन क्षेत्र को जोड़ता है। इस हाई–वे का 887 वर्ग कि0मी0 क्षेत्र पाकिस्तान एवं 413 वर्ग कि0मी0 क्षेत्र चीन में पड़ता है। यह हाई–वे सन् 1979 में पूरा बनकर तैयार हो गया था। आधिकारिक तौर पर इसे पाकिस्तान में एन–35 और चीन में एन0एच–314 के नाम से पुकारा जाता है। इस मार्ग से चीन–पाकिस्तान को आर्थिक एवं सैनिक सहायता पहुंचाता है।[3]

भारत–पाक युद्ध सन् 1965 में चीन ने खुलकर पाकिस्तान का समर्थन किया, जितनी भारत–पाकिस्तान सम्बन्धों में कटष्ता आती गयी उतने ही चीन–पाकिस्तान सम्बन्ध मधुर होते गये। दोनों देशों के प्रतिनिधि एवं शिष्ठ मण्डलों के आदान–प्रदान द्वारा सम्बन्ध और अधिक प्रगाड होते गये। सन् 1966 से चीन ने भारी मात्रा में पाकिस्तान को हथियारों की आपूर्ति शुरु कर दी। चीन स्वयं दक्षिण एशिया में अपना विस्तार चाहता था और पाकिस्तान जैसा मित्र पाकर वह भारत विरोधी गतिविधियों में सक्रिय हो गया। सन् 1971 में भारत द्वारा मिली पराजय और विभाजन को पाकिस्तान वर्दाश्त नहीं कर पाया। पाकिस्तान इस बात को पूर्णतः स्वीकार कर चुका था कि भारत से प्रत्यक्ष रुप में लड़ाई में जीत पाना असम्भव है इसलिए उसने प्रौक्सी युद्ध का सहारा लेकर भारत से लड़ने की नीति अपनायी। आंतकवादी गतिविधियों को बढ़ावा देकर एवं उन्हें अपनी रक्षा एवं विदेश नीति में अहम् स्थान देकर भारत को अस्थिर करना शुरु किया। सन् 1970 के दशक से चीन–पाकिस्तान के मध्य आर्थिक, राजनैतिक, व्यापारिक, वाणिज्यिक, सैनिक, सांस्कृतिक, वैज्ञानिक एवं तकनीकि सम्बन्धों में मजबूती आने लगीं। दोनों के सम्बन्ध आंतरिक शासन तंत्र के परिवर्तन के बाबजूद भी बरकरार रहे। चीन से घनिष्ठ सम्बन्ध बनाना पाकिस्तान की विदेशनीति का केन्द्रीय हिस्सा रहा है। सन् 1986 में पाकिस्तान के प्रधानमंत्री मुहम्मद जियाऊल हक ने चीन की यात्रा कर दोनों देशों के सम्बन्धों को उजागर किया। सन् 1989 में चीन के तियानमेन

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...योगिकी एवं सुरक्षा चुनौतियां

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किसी भी लक्ष्य की प्राप्ति के लिए साधनों की आवश्यकता होती है। उनमें से अधिकांश भौतिक, मानवीय, मनौवैज्ञानिक तथा बौद्धिक होते हैं। उदाहरण के लिए किसी कारखाने में उत्पादन रूपी साध्य को प्राप्त करने के लिए अधीक्षक, इंजीनियर तथा कारीगरों के लिए श्रेष्ठ औजार और मशीनों की आवश्यकता होती है। ठीक उसी प्रकार जब कोई राष्ट्र शत्रु राष्ट्र से युद्ध द्वारा निपटने का निश्चय करता है तो युद्ध के लक्ष्य की प्राप्ति के लिए उसे विभिन्न प्रकार की सेनाओं, साज–सज्जा एवं हथियारों की आवश्यकता पड़ती है। यदि यह साधन श्रेष्ठ प्रकार के नहीं हैं तो युद्ध का लक्ष्य हासिल नहीं किया जा सकता। इसी कारण इन साधनों के बारे में जानकारी की विशेष आवश्यकता होती है। वर्तमान समय में कोई भी राष्ट्र प्रत्यक्ष युद्ध करने से बचता है। इसका मुख्य कारण प्रथम तथा द्वितीय विश्व युद्ध के बाद तकनीकी और परमाणु बमों, सूचना प्रौद्योगिकी के कारण जो क्रान्तिकारी परिवर्तन हुये है उनसे युद्ध की विभीषिका का अन्दाजा भी नहीं लगाया जा सकता कि युद्ध में राष्ट्रों को कितनी क्षति का सामना करना पड़ेगा। वर्तमान में जो भी प्रत्यक्ष युद्ध लड़ा गया उसमें सम्पूर्ण राष्ट्र प्रभावित हुआ और अगर आगे भी ऐसे युद्ध होते हैं तो भी राष्ट्रों को क्षति का सामना करना पड़ेगा।

प्रथम विश्व युद्ध में रासायनिक जैविकीय हथियारों के प्रयोगों ने राष्ट्रों के मनोबल को सीधे तौर पर प्रभावित किया और वायुयान के प्रयोग ने क्रान्तिकारी परिवर्तन का आगाज किया जिससे उत्तरोत्तर इसका विकास होता गया और द्वितीय विश्व युद्ध में रासायनिक हथियारों, जीवाणु प्रहार, परमाणु विमानों ने अपनी महत्वपूर्ण भूमिका का निर्वाह कर युद्ध का जो विकराल रूप प्रस्तुत किया उसे मानव जाति के लिये भूल पाना कठिन है।[1] आज के परिप्रेक्ष्य में विकास की परिभाषा कोई नई अवधारणा नहीं है। विकास का नियम तो यही है कि जो जीव अपने–आप को वातावरण के अनुकूल ढालने के प्रयास में सफल हो जाते हैं वहीं जीवित भी रह पाते हैं। यही विधान सैनिक संगठनों का भी है क्योंकि सैनिक संगठन भी एक जीव समूह है। इसलिए सैनिकों को सभ्यता के अनुसार ही बदलना चाहिए अन्यथा युद्ध विफल हो जायेगा। इस सम्बन्ध में सबसे महत्वपूर्ण बात यह है कि यन्त्रों का विकास किस निश्चित विधान के अनुसार हुआ। आज राष्ट्रों को अपनी सुरक्षा को खतरा प्रत्यक्ष युद्ध का इतना नही है। आज के युद्ध बन्द कमरों में लड़े जाते है अर्थात सूचना के युग में कोई भी व्यक्ति सूचना क्रान्ति से अछूता नहीं है। आज वही राष्ट्र शक्तिशाली है जिसके पास सूचना तथा प्रौद्योगिकी पर उसका नियत्रंण है। आज अमेरिका अपनी तकनीकी शक्ति तथा विशाल सूचनातंत्र के बल पर सुपर पावर बना हुआ है और तकनीकी के बल पर ही चीन दूसरी महाशक्ति बनने के कगार पर है या कहें कि बन चुका है तो अतिशियोक्ति नही होगी।[2] सैन्य प्रौद्योगिकी के क्षेत्र में हुये परिवर्तन के सन्दर्भ में हथियारों को परिभाषित करते हुये बेडले ए0 फिल्मी0 ने कहा है कि "एक औजार उस समय हथियार के रूप में परिणित हो जाया करता है जब उसको आक्रमण करने अथवा प्रतिरक्षा के लिए प्रयोग में लाया जाता है।" कहने का तात्पर्य है कि यदि कोई मिट्टी का बर्तन शत्रु को आहत करने की दृष्टि से प्रयोग किया जाये अथवा उसके द्वारा हताहत करने की चेष्टा की जाये तो वह उस समय के लिए हथियार का रूप धारण कर लेता है। आज सूचना और प्रौद्योगिकी के विकास ने इतना विकास कर लिया है कि इनके बारे में जानकारी करना और उनमें नये–नये बदलावों को करना हर राष्ट्र का अपना एक महत्वपूर्ण कार्य बन गया है।[3] वर्तमान में चिन्ता इस बात की है कि सोशल मीडिया ने इतना मजबूत और व्यापक रूप धारण कर लिया है कि वह हिंसा को एक क्षेत्र से दूसरे क्षेत्र में राजनीतिक व भौगोलिक सीमाओं के बावजूद फैला रहा है। सोशल मीडिया जिस तरह से अच्छी, बुरी और गढ़ी हुयी खबरों को स्मार्ट फोन, लैपटाप, कंप्यूटर आदि के माध्यम से फैलाता है जिनमें फर्जी तस्वीरें, अफवाहों, एसएमएस, और व्हाटसअप, फेसबुक पोस्ट के तौर पर सामने आ रही हैं, हिंसा का नया रूप देखने को मिल रहा है। बंगलुरू, बोधगया, राजस्थान की जातीय हिंसा जैसी घटनाओं को एक कड़ी के रूप में देखा जाना चाहिये। यह हिंसा का नया चरण है और इसके पास प्रसार का नया माध्यम भी है।[4]

प्रौद्योगिकी के उपकरण (Tools of Information Technology)

(Radar)– यदि हम रडार (Radar) शब्द का विश्लेषण करें तो इसका अर्थ निम्न होगा–

RADIO (रेडियो), D–DETECTION (दिशा निर्धारण), A–AND (और), R-RANGINAL (दूरीमाप)

इस यंत्र का नाम 'रेडियो' दिशा और दूरी माप' (Radio, direction and Ranging) के आधार पर पड़ा है। इसमें वो (Electro Magnetic) तंरगों को प्रवाहित किया जाता है, जिनकी गति 189000 मील/सेकेण्ड होती है। जिस प्रकार हम अपनी ध्वनि की प्रतिध्वनि को सुनकर आभास कर लेते है कि यह कितनी दूरी से लौट कर आ रही है। ठीक

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सूचना प्रौद्योगिकी एवं सुरक्षा चुनौतियां

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किसी भी लक्ष्य की प्राप्ति के लिए साधनों की आवश्यकता होती है। उनमें से अधिकांश भौतिक, मानवीय, मनौवैज्ञानिक तथा बौद्धिक होते हैं। उदाहरण के लिए किसी कारखाने में उत्पादन रूपी साध्य को प्राप्त करने के लिए अधीक्षक, इंजीनियर तथा कारीगरों के लिए श्रेष्ठ औजार और मशीनों की आवश्यकता होती है। ठीक उसी प्रकार जब कोई राष्ट्र शत्रु राष्ट्र से युद्ध द्वारा निपटने का निश्चय करता है तो युद्ध के लक्ष्य की प्राप्ति के लिए उसे विभिन्न प्रकार की सेनाओं, साज–सज्जा एवं हथियारों की आवश्यकता पड़ती है। यदि यह साधन श्रेष्ठ प्रकार के नहीं हैं तो युद्ध का लक्ष्य हासिल नहीं किया जा सकता। इसी कारण इन साधनों के बारे में जानकारी की विशेष आवश्यकता होती है। वर्तमान समय में कोई भी राष्ट्र प्रत्यक्ष युद्ध करने से बचता है। इसका मुख्य कारण प्रथम तथा द्वितीय विश्व युद्ध के बाद तकनीकी और परमाणु बमों, सूचना प्रौद्योगिकी के कारण जो क्रान्तिकारी परिवर्तन हुये है उनसे युद्ध की विभीषिका का अन्दाजा भी नहीं लगाया जा सकता कि युद्ध में राष्ट्रों को कितनी क्षति का सामना करना पड़ेगा। वर्तमान में जो भी प्रत्यक्ष युद्ध लड़ा गया उसमें सम्पूर्ण राष्ट्र प्रभावित हुआ और अगर आगे भी ऐसे युद्ध होते हैं तो भी राष्ट्रों को क्षति का सामना करना पड़ेगा।

प्रथम विश्व युद्ध में रासायनिक जैविकीय हथियारों के प्रयोगों ने राष्ट्रों के मनोबल को सीधे तौर पर प्रभावित किया और वायुयान के प्रयोग ने क्रान्तिकारी परिवर्तन का आगाज किया जिससे उत्तरोत्तर इसका विकास होता गया और द्वितीय विश्व युद्ध में रासायनिक हथियारों, जीवाणु प्रहार, परमाणु विमानों ने अपनी महत्वपूर्ण भूमिका का निर्वाह कर युद्ध का जो विकराल रूप प्रस्तुत किया उसे मानव जाति के लिये भूल पाना कठिन है।[1] आज के परिप्रेक्ष्य में विकास की परिभाषा कोई नई अवधारणा नहीं है। विकास का नियम तो यही है कि जो जीव अपने–आप को वातावरण के अनुकूल ढालने के प्रयास में सफल हो जाते हैं वहीं जीवित भी रह पाते हैं। यही विधान सैनिक संगठनों का भी है क्योंकि सैनिक संगठन भी एक जीव समूह है। इसलिए सैनिकों को सभ्यता के अनुसार ही बदलना चाहिए अन्यथा युद्ध विफल हो जायेगा। इस सम्बन्ध में सबसे महत्वपूर्ण बात यह है कि यन्त्रों का विकास किस निश्चित विधान के अनुसार हुआ। आज राष्ट्रों को अपनी सुरक्षा को खतरा प्रत्यक्ष युद्ध का इतना नही है। आज के युद्ध बन्द कमरों में लड़े जाते है अर्थात सूचना के युग में कोई भी व्यक्ति सूचना क्रान्ति से अछूता नहीं है। आज वही राष्ट्र शक्तिशाली है जिसके पास सूचना तथा प्रौद्योगिकी पर उसका नियत्रंण है। आज अमेरिका अपनी तकनीकी शक्ति तथा विशाल सूचनातंत्र के बल पर सुपर पावर बना हुआ है और तकनीकी के बल पर ही चीन दूसरी महाशक्ति बनने के कगार पर है या कहें कि बन चुका है तो अतिशियोक्ति नही होगी।[2] सैन्य प्रौद्योगिकी के क्षेत्र में हुये परिवर्तन के सन्दर्भ में हथियारों को परिभाषित करते हुये बेडले ए0 फिल्मी0 ने कहा है कि "एक औजार उस समय हथियार के रूप में परिणित हो जाया करता है जब इसको आक्रमण करने अथवा प्रतिरक्षा के लिए प्रयोग में लाया जाता है।" कहने का तात्पर्य है कि यदि कोई मिट्टी का शत्रु को आहत करने की दृष्टि से प्रयोग किया जाये अथवा उसके द्वारा हताहत करने की चेष्टा की जाये तो वह उस समय के लिए हथियार का रूप धारण कर लेता है। आज सूचना और प्रौद्योगिकी के विकास ने इतना विकास किया है कि इनके बारे में जानकारी करना और उनमें नये–नये बदलावों को करना हर राष्ट्र का अपना एक सतत कार्य बन गया है।[3] वर्तमान में चिन्ता इस बात की है कि सोशल मीडिया ने इतना मजबूत और व्यापक रूप धारण कर लिया है कि वह हिंसा को एक क्षेत्र से दूसरे क्षेत्र में राजनीतिक व भौगोलिक सीमाओं के बावजूद फैला रहा है। सोशल मीडिया जिस तरह से अच्छी, बुरी और गढ़ी हुयी खबरों को स्मार्ट फोन, लैपटाप, कंप्यूटर आदि के माध्यम से फैलाता है जिनमें फर्जी तस्वीरें, अफवाहों, एसएमएस, और व्हाटसअप, फेसबुक पोस्ट के तौर पर सामने आ रही हैं, हिंसा का नया रूप देखने को मिल रहा है। बंगलुरू, बोधगया, राजस्थान की जातीय हिंसा जैसी घटनाओं को एक नयी के रूप में देखा जाना चाहिये। यह हिंसा का नया चरण है और इसके पास प्रसार का नया माध्यम भी है।[4]

प्रौद्योगिकी के उपकरण (Tools of Information Technology)

Radar)– यदि हम रडार (Radar) शब्द का विश्लेषण करें तो इसका अर्थ निम्न होगा–

ADIO (रेडियो), D–DETECTION (दिशा निर्धारण), A–AND (और), R-RANGINAL (दूरीमाप)

इस यंत्र का नाम 'रेडियो' दिशा और दूरी माप' (Radio, direction and Ranging) के आधार पर पड़ा है। इसमें (Electro Magnetic) तंरगों को प्रवाहित किया जाता है, जिनकी गति 189000 मील/सेकेण्ड होती है। जिस से अपनी ध्वनि की प्रतिध्वनि को सुनकर आभास कर लेते है कि यह कितनी दूरी से लौट कर आ रही है। ठीक

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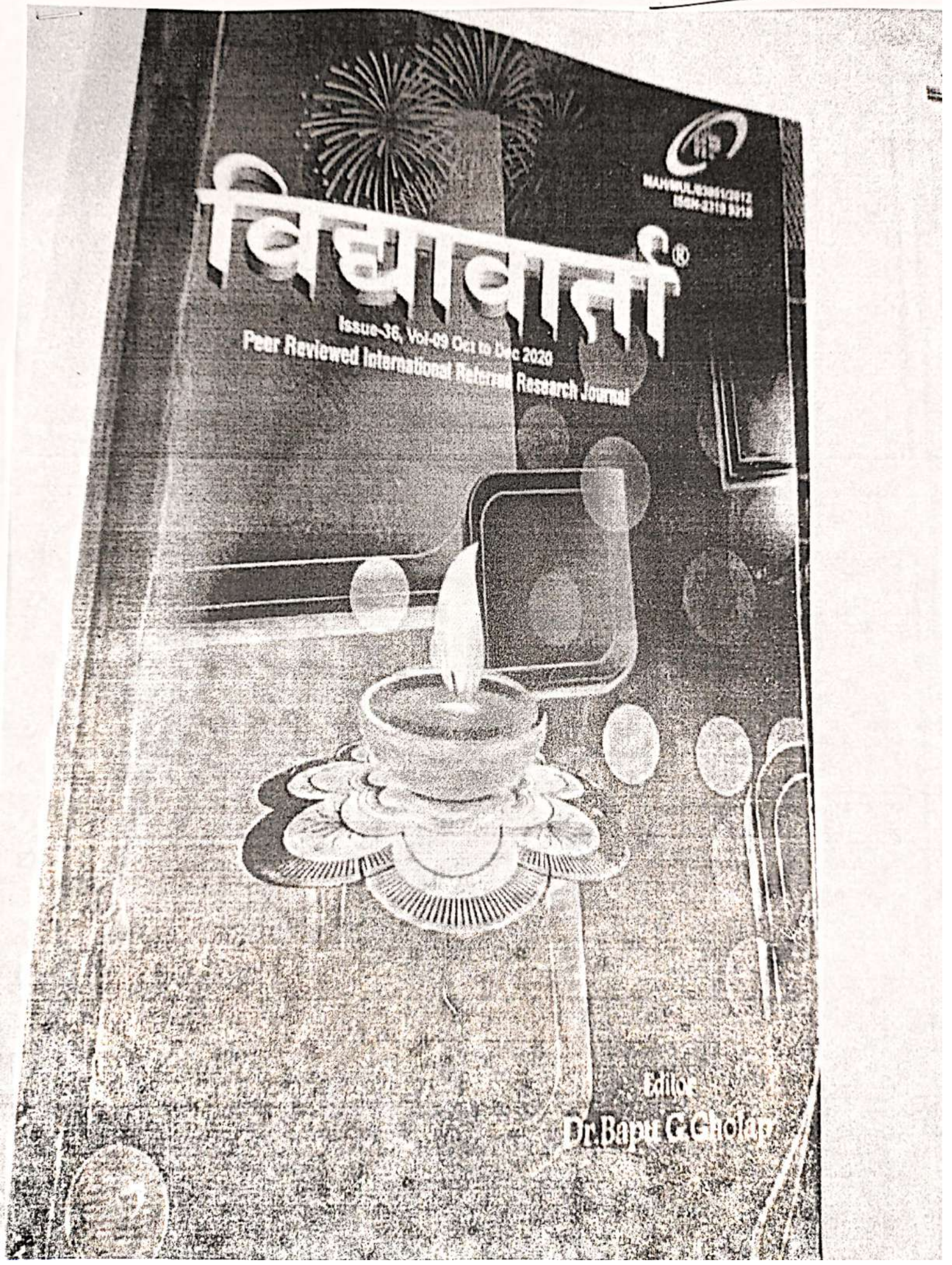

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कत्यूरी राजवंश की प्रशासनिक व्यवस्था

कु॰ अर्चना
शोधार्थिनी
रक्षा, स्त्रॉतेजिक एवं भू–राजनीति विभाग
हे॰न॰ब॰ गढ़वाल (केन्द्रीय) विश्वविद्यालय
श्रीनगर गढ़वाल (उत्तराखण्ड)

प्रो॰ भारती चौहान
शोध निर्देशिका रक्षा,
स्त्रॉतेजिक एवं भू–राजनीति विभाग
हे॰न॰ब॰ गढ़वाल (केन्द्रीय) विश्वविद्यालय
श्रीनगर गढ़वाल (उत्तराखण्ड)

इतिहास को देखने के लिए उसमें डूबना पड़ता है और भूगोल को समझने के लिए उसमें खोना पड़ता है। हम यदि अपने आस–पास मौजूद इन ऐतिहासिक धरोहरों को ध्यानपूर्वक समझने का प्रयास करें तो वे बहुत कुछ कहती हैं। इनमें राष्ट्रभक्ति में डूबे वीर रस की अनुभूति भी होती है तो गौरवशाली इतिहास के शौर्य की अनकही दास्तां भी। उत्तराखंड का ऐसा ही ख्याति प्राप्त व वीर रस में डूबा कत्यूरी राजवंश का इतिहास में महत्वपूर्ण स्थान रहा है। कत्यूरी राजवंश का केवल उत्तराखंड के इतिहास में ही नहीं वरन् भारतवर्ष के इतिहास में भी महत्वपूर्ण स्थान है। इस राजवंश ने अपने शौर्य, पराक्रम के बल पर लगभग २५० वर्षों तक तिब्बत के छापा मारों को उत्तर भारत पर लूट–मार के अभियान चलाने से रोके रखा। इस वंश के काल में उत्तराखंड की संस्कृति सबसे ज्यादा पल्लवित, पुष्पित व फलित हुई। कत्यूरी राजवंश ने मध्य–हिमालय में प्रथम बार राजनीतिक एकता स्थापित की और सांस्कृतिक क्षेत्र में आरम्भकालीन वास्तु की मूल्यवान छाप छोड़ी। कत्यूरी राजाओं के शौर्य, पराक्रम राज्य की प्रशासनिक व्यवस्था व संस्कृति के प्रति विशेष लगाव का वर्णन–काव्य संकलन इतिहास के गौरवशाली पृष्ठ में सुरक्षितियों को सीखने में कामयाब रहा।

कत्यूरी राजवंश की उत्पत्ति एवं स्थापना :

कत्यूरी राजवंश को इतिहासकारों ने उत्तराखंड का प्रथम स्वतंत्र शक्तिशाली एवं राजनीतिक एकता स्थापित करने वाला राजवंश माना है। सम्राट हर्षदेव कि की मृत्यु के पश्चात् उत्तराखंड की राजनीति में संकट की स्थिति उत्पन्न हो गयी थी। राजनैतिक अस्थिरता के इस काल में इस क्षेत्र में पौरवों का ब्रह्मपुर राज्य, सायुक्त राज्य, गोविषाण राज्य, सुवर्णगोत्र राज्य व कल्याणवर्मन का राज्य अस्तित्व में आये। ब्रह्मपुर राज्य उस समय का सबसे विशाल व समृद्ध राज्य था। इस राज्य का विस्तार पूर्वी गढ़वाल से लेकर कुमाऊं के ज्यादातर भाग पर था। ६७५ ई० में इस राज्य का पतन हो गया था। ब्रह्मपुर राज्य के पतन के साथ ही कत्यूरी राजवंश का उदय हुआ। पौरवों के ब्रह्मपुर राज्य के पतन के पश्चात मध्य हिमालय सतलज से लेकर पश्चिम नेपाल तक अनेक छोटे–बड़े कबीलाई राज्यों में बंट गया था। इसी राजनैतिक अस्थिरता का लाभ उठाकर प्राचीन कुणिंदों की एक शाखा ने अपनी शक्ति को बढ़ाते हुये इन छोटे–बड़े कबीलाई राज्यों को विजित कर उत्तर–पश्चिम गढ़वाल में एक शक्तिशाली राजवंश के रूप में पदार्पण किया। जो इतिहास में कार्तिकेयपुर (कत्यूरी) राजवंश के रूप में प्रसिद्ध हुआ। कत्यूरी राजवंश ने उत्तराखण्ड में तीन शताब्दी तक एक छत्र शासन किया।[१] कत्यूरी राजवंश ने सन् ७९७ वि० से लगभग १०५७ वि० तक कार्तिकेयपुर राजधानी से व इसके पश्चात् सन् १६४८ तक असकोट राजधानी से उत्तराखंड पर एक छत्र शासन किया। इतिहास में इतने लम्बे समय तक किसी क्षेत्र में शासन करने वाले राजवंश कम ही देखने को मिलते हैं।[२]

कत्यूरी राजवंश की उत्पत्ति को लेकर भी विद्वान एक मत नहीं है। सर्वप्रथम एटकिन्सन ने अपने महाग्रन्थ "गजेटियर ऑफ हिमालयन डिस्ट्रिक्ट

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अयन

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भारत एवं चीन के बीच बफर स्टेट के रूप में नेपाल एवं भूटान की भूमिका

Nepal and Bhutan's Role As A Buffer State between India and China

Paper Submission: 12/02/2021, Date of Acceptance: 21/02/2021, Date of Publication: 22/02/2021

विकास शर्मा
पूर्व शोधार्थी,
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श्रीनगर, गढ़वाल, उत्तराखण्ड, भारत

सारांश

एशियाई दिग्गज भारत और चीन क्षेत्रीय एवं वैश्विक स्तर पर दबदबा बनाने के लिए निरन्तर प्रयासरत रहे है। भूटान और नेपाल के साथ भारत के सदियों पुराने संबंध है। भूटान–नेपाल ऐसे दो पड़ोसी देश है जिनका भारत के साथ सामरिक एवं रणनीतिक संबंध एक परम्परा के रूप में स्वतंत्रता के समय से चले आ रहे है। भारत को घेरने की रणनीति के तहत चीन अपनी राजनीतिक चालों से हमें मात देने के निरन्तर प्रयास कर रहा है, चीन अपना प्रभुत्व बफर स्टेट में बढ़ाने के लिए आधारभूत संरचनाओं के विकास में भारी निवेश कर रहा है, ताकि भारतीय सीमाओं तक अपनी आसान पहुँच बना सके। वर्तमान में भारतीय रक्षात्मक दृष्टि से भूटान और नेपाल का सामरिक दृष्टिकोण से बहुत महत्व है, जिस प्रकार चीन अपनी 'चैकबुक' नीति अपनाकर जो हस्तक्षेप कर रहा है वह इन देशों की आन्तरिक समस्याओं का प्रत्यक्ष प्रभाव भी हमारी सुरक्षा व्यवस्था को प्रभावित करता है। बदलते वैश्विक परिवेश एवं बनते नये सामरिक समीकरणों को दृष्टि में रखते हुए इन राष्ट्रों के प्रति व्यापक रणनीति बनाने की आवश्यकता है।

Asian giants India and China have been striving to dominate at the regional and global level. India has a centuries-old relationship with Bhutan and Nepal. Bhutan-Nepal are two neighboring countries whose strategic relations with India have been a tradition since the time of independence. As a strategy to encircle India, China is constantly trying to beat us with its political moves. China is investing heavily in the development of infrastructures to increase its dominance in the buffer state, so that it can have easy access to Indian borders. Currently, Bhutan and Nepal are of great importance from the Indian defensive point of view, just as the intervention that China is taking by adopting its 'checkbook' policy, the direct impact of the internal problems of these countries also affects our security system. There is a need to formulate a comprehensive strategy towards these nations keeping in view the changing global environment and the new strategic equations being formed.

मुख्य शब्द : अन्तस्थ, आयुध, स्वायत्तशासी, माओवाद, बी.आर.आई., ड्रेगन।
Antastha, Ayudha, Autonomous, Maoism, BRI, Dragon

प्रस्तावना

दो परस्पर शत्रु राष्ट्रों के मध्य स्थित अन्तस्थ बफर राष्ट्र का महत्व अत्यंत प्राचीन काल से ही रहा है। अन्तस्थ राष्ट्र के अस्तित्व के कारण ही दो शत्रु देश को युद्ध से पृथक रह पाते थे बफर राष्ट्र की नीति का उपयोग ब्रिटिश शासकों द्वारा 1765 से 1947 तक प्रभावी रूप से किया गया। अंतर्राष्ट्रीय पटल पर बदलते राजनीतिक परिदृश्य के कारण और अपने राष्ट्रीय हितों की पूर्ति के कारण किसी भी राष्ट्र का स्वरूप स्थाई अस्थाई हो गया है। नेपाल राष्ट्र हिमालय के दक्षिण ढलान पर भारत एवं चीन के बीच में स्थित है, जो [illegible] (बफर स्टेट) रहा दूसरी ओर भारतीय सुरक्षा के लिए अत्यधिक सामरिक महत्व का क्षेत्र है, क्योंकि नेपाल चीन के [illegible] के लिए काफी [illegible] है और इसी कारण से भारतीय सुरक्षा [illegible] की दृष्टि से पूर्ण हुआ है।

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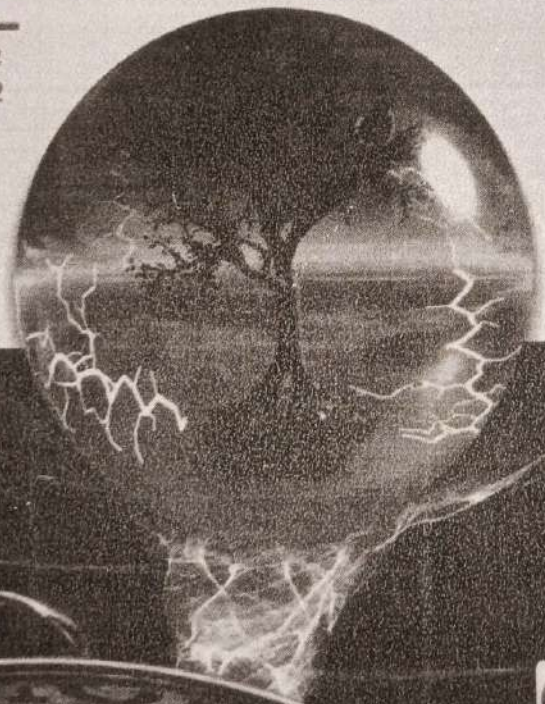

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Asian giants India and China have been striving to dominate at the regional and global level. India has a centuries-old relationship with Bhutan and Nepal. Bhutan-Nepal are two neighboring countries whose strategic relations with India have been a tradition since the time of Independence. As a strategy to encircle India, China is constantly trying to beat us with its political moves, China is investing heavily in the development of infrastructures to increase its dominance in the buffer state, so that it can have easy access to Indian borders. Currently, Bhutan and Nepal are of great importance from the Indian defensive point of view, just as the intervention that China is taking by adopting its 'checkbook' policy, the direct impact of the internal problems of these countries also affects our security system. There is a need to formulate a comprehensive strategy towards these nations keeping in view the changing global environment and the new strategic equations being formed.

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Antasthā, Ayudha, Autonomous, Maoism, BRI, Dragon.

प्रस्तावना

दो परस्पर शत्रु राष्ट्रों के मध्य स्थित अनअस्थ या बफर राष्ट्र का महत्व प्राचीन काल से ही रहा है। अनअस्थ राष्ट्र के अस्तित्व के कारण ही दो शत्रु देश के युद्ध से बचने में सफल रहे पाते थे बफर राष्ट्र की नीति का अनुसरण विभिन्न शासकों द्वारा 1704 से 1801 तक हमले रोकने के लिया गया। अंतर्राष्ट्रीय और घरेलू राजनीतिक परिदृश्य के अलावा और अपने राष्ट्रीय हितों की पूर्ति के लिए किसी भी राष्ट्र को सहायता देना आरम्भ हो जाता है। नेपाल राष्ट्र हितधारकों के सक्रिय समर्थन पर भारत एवं चीन के बीच में स्थित है। दो महाशक्तियों के मध्य स्थित नेपाल एक मौन सहायक (बफर स्टेट) जैसा सुरक्षा और संतुलन की भूमिका के लिए अन्तर्राष्ट्रीय महत्व को देता है क्योंकि नेपाल एक से हितधारकों के लिए उसके द्वार है और इसी कारण से भारतीय सुरक्षा संगठन भारतीय महान की सुरक्षा से जुड़ा हुआ है।

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अंक-116
नवम्बर 2021

भारत की विदेश नीति

भाग:1

अगला अंक
भारत की विदेश नीति
भाग: 2

अफगानिस्तान की वर्तमान स्थिति से प्रभावित होती भारतीय विदेश नीति

डॉ. भारती चौहान और देवकी नन्दन

प्रस्तावना

राष्ट्र–राज्य व्यवस्था की उत्पत्ति के साथ राष्ट्रीय सुरक्षा राष्ट्रों का प्रमुख ध्येय रहा है। इसी को ध्यान में रखकर प्रत्येक राष्ट्र के नीति निर्माता अपनी नीति का निर्धारण कर दूसरे राष्ट्रों के साथ सम्बन्धों में अपने राष्ट्रीय हितों को साधने का अभीष्टतम प्रयास करते हैं, इसे ही विदेश नीति कहते हैं। जार्ज मौडेलस्की के अनुसार " विदेश नीति देशों द्वारा विकसित दूसरे देशों के व्यवहार को बदलने वाले कार्यों की व्यवस्था तथा अन्तर्राष्ट्रीय वातावरण में अपने कार्यों का समायोजन है।'

वर्तमान भू–मण्डलीकरण एवं भू–राजनीति के युग में रक्षा, विदेश, सुरक्षा तथा घरेलू नीतियों के तार एक दूसरे से अभिन्न रूप से जुडे हुए हैं, इन्हीं मूल्यों को ध्यान में रखकर विदेश नीति का मूर्त रूप निर्धारित होता है। इसी के माध्यम से राष्ट्र अपनी स्वतन्त्रता, समृद्धि एवं अस्तित्व का परिरक्षण करते हैं।

डॉ. भारती चौहान, एसोसियेट,
रक्षा स्ट्रेटेजिक एंव भू राजनितिक अध्ययन विभाग, हे.न.ब. गढ़वाल विश्वविद्यालय श्रीनगर गढ़वाल, उत्तराखण्ड
देवकी नन्दन,
शोध छात्र – रक्षा स्ट्रेटेजिक एंव भू राजनितिक अध्ययन विभाग

प्राचीन समय से ही पश्चिमी सीमान्त में स्थित अफगानिस्तान का भारत के लिए एक स्त्रात्रेजिक महत्व रहा है। अफगानिस्तान के आन्तरिक परिस्थितियों का प्रत्यक्ष एवं अप्रत्यक्ष प्रभाव भारत पर पड़ा है। अगर हम मध्यकालीन इतिहास में दर्पष्टिपात करते हैं तो पाते हैं कि अफगानिस्तान ही वह भू–भाग है, जहाँ से भारत में गजनी, गौरी, तुर्कों, मुगलों एवं अहमदशाह अब्दाली जैसे अक्रान्ताओं ने आक्रमण कर एवं साम्राज्य स्थापित कर सम्पूर्ण भारतीय उप महाद्वीप की राजनीतिक, आर्थिक, सांस्कर्पतिक एवं धार्मिक दिशा दशा तय की।

19वीं सदी में ब्रिटिश और रूसी साम्राज्यों के बीच अफगानिस्तान और पड़ोसी पश्चिम और दक्षिण क्षेत्रों पर एकाधिकार और प्रभाव के लिए संघर्ष 'द ग्रेट गेम' नाम से जाना जाता है। ब्रिटेन ने अग्रगामी नीति का पालन किया पर असफलता हाथ लगी। लार्ड एलनबरो ने घोषणा किया कि वह अफगानिस्तान में किसी भी ऐसी सरकार को स्वीकार लेगा कि जिसे अफगानों का समर्थन प्राप्त हो। तीन ऑग्ल अफगान युद्ध (1839–42, 1878–80, 1919–21) लड़ने के बावजूद ब्रिटिश सरकार अफगानिस्तान में असफल रही। परिणामस्वरूप ब्रिटिश सरकार ने अफगानिस्तान के आन्तरिक मामलों में हस्तक्षेप की नीति त्याग कर 'कुशल अकर्मण्यता की नीति' का प्रयोग किया।[2]

अफगानिस्तान में ब्रिटिश भारत सरकार के असफल प्रयास के बाद 20वीं सदी के अन्त में सोवियत यूनियन ने हस्तक्षेप कर नियंत्रण स्थापित करने का प्रयास किया, परन्तु असफलता हाथ लगी। 9/11 हमले के बाद अमेरिका ने आपरेशन इंड्यूरिंग फ्रीडम' के तहत आतंक के विरूद्ध वैश्विक युद्ध की घोषणा की एवं तालिबान के अलकायदा गठजोड को नेस्तानाबूद कर हामिद करजई के नेतष्त्व में अफगानिस्तान में स्थिरता लाने का प्रयास किया।[3]

15 अगस्त, 2021 का अफगानिस्तान में तालिबान ने काबुल पर कब्जा कर वर्तमान राष्ट्रपति अशरफगनी को देश छोड़कर भागने पर मजबूर कर

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INDIA'S SECURITY CHALLENGES IN THE 21ST CENTURY

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Abstract
National security is of paramount importance to any nation. It deals with the capability of a nation to secure against any threats that may arise given the contemporary geopolitical situation. Given India's gradual growth and popularity in Indo-Pacific, it faces certain internal and external challenges. These security challenges require robust consideration. India has two nuclear-powered neighbors, who are rapidly developing their military capabilities, thus, it generates a security dilemma. In view of the above fact, it is imperative to balance the challenging strategic environment. With the advent of traditional and non-traditional security threats, the security dimensionsare spontaneously widening, paving the way to the emergence of contemporary hybrid threats. This paper intends to highlight the contemporary Security Challenges that India faces, their futuristic implications, and suggestions to provide a holistic elucidation of the problem of India's security.
Keywords-Artificial intelligence, Health Security, Hybrid warfare, the National Register of Citizens, **National Security,** Student Islamic Movement of India.

Introduction

India is one of the largest democracies of the world, and an emerging power in South Asia.However, due to its geopolitical location it has certain threats that consistently challenge India's National Security and integrity. By the end of the cold war, a new order emerged altering the existing one in conformity with the contemporary international geopolitics.The bipolar world followeda multipolar world, with the emergence of the US, Russia, China, Japan competing for power in international power politics.Due to the above reason the supreme elementfor attaining security became supremacy in power. It specifically entails, technological, social, economic, infrastructural and, political power.[1]With the advancement of technology,security challenges are exponentially changing, with the inclusion of Hybrid warfare andHybrid threats.[2]A serious challenge for India is to confront its immediate hostilenuclear-powered neighbors, who possess military might and are progressively building their capabilities.[3]

After the sudden outbreak of Covid-19 pandemic, a serious concern for health securityhas also emerged worldwide, itwas overlooked long before.[4]

The emergence of the Taliban regime in Afghanistan, also posesa serious concernfor India's security. In view of the above reasons, it is imperative tore-evaluate and redesign India's national security strategy in order to counter the prevailing or future challenges.[5]

India's Security Challenges: overview

Security for a nation is the ability to secure its interests from potential threats. It remains a challenge for India, owing to the complexity of perpetual traditional and non-traditional threatsthat try to destabilize India's security.[6]A security challenge arises from some internal and external elementsthat intend to destabilize a country's security. India has repeatedly faced internal and external challenges due to its vast territory and population. Some of the internal security challenges associated with India are Insurgency in the northeast, Naxalism, ethnic and communal violence, etc. Due to India's porous border with Pakistan, China, Nepal, Myanmar, and Bangladesh, it highly vulnerable to intrusion. These wide range of security threats need a pragmatic approach to counter various security challenges.7

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CHINESE HYBRID WARFARE STRATEGY: A THREAT TO INDIA'S NATIONAL SECURITY

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Abstract
This review study explores China's hybrid warfare strategy of subduing the enemy without fighting a direct war, by psychological, media and law warfare. China has been trying to jeopardize India's national security to counter the USA and India's strategic partnership to emerge as a sole superpower in the Asian continent and beyond. China has been seen using various ways to make India's national security vulnerable like extracting sensitive and valuable information, encroachment at borders, frequent skirmish under the threshold of conventional war and many more discussed below in detail. This Study will also try to suggest how to mitigate the Chinese hybrid strategy to maintain India's strategic autonomy.

Keywords: Hybrid warfare, Nuclear weapons, National Security, Strategy, War and Peace

Introduction

The Concept of hybrid warfare has taken place as a traditional or non-traditional means employs to support military force by irregular and cyber warfare tactics. Therefore, in hybrid warfare, any state could be in the grip of attack, but it will be oblivious that who is attacking and which tools he is utilizing to the onslaught. In this nuclear age due to the availability of lethal nuclear weapons with the high-speed transportation system in the form of ICBM and supersonic missiles, it is an uphill task for a nation to gambit war as a means to fulfil its ends because a total war will be a nuclear war, further, it could annihilate the entire human civilization. Owning to this condition and dusky complexion of full-scale war China upholds stratagem and hybrid warfare against India without fighting a direct war under the threshold of overt conflict. There exists no universal definition of hybrid warfare, but it can be speculated by its nature and means of deployments that it is a decentralized method of warfare not only during wartime but also in peacetime by blurring a line between war and peace. According to great Chinese thinker Sun-Tzu (Tzu, 2012), ''The supreme art of war is to subdue the enemy without fighting'', Chinese ambitions to become the sole superpower in the Asian continent could jeopardize India's national security. Rising China is a tangible threat to India's national security as we have seen from a long span with its capacity (Economic, military, resources), intention (strategic or objective); image (perception about the targeted nation) (Gopal Singh, 2005). It could exacerbate India's national security; India needs to prepare counter hybrid warfare to curb and crackdown Chinese hybrid warfare.

Background of The Study:

Concept of Hybrid Warfare (War beyond rules):

We are living in a global world. Due to globalization and technological advancement humanity has been experiencing a tremendous change in every ordinary business of life, Security studies aren't its exception. Further owning to this condition there is a manifestation of interconnectedness among states as we have seen in the cobweb model and billiard ball model (Heywood, 2011). In the contemporary world, international borders are so porous, by dint of it, there is a free flow of information, technology, men, money, and materials across the borders (Gandhi, 2010). Beyond it, our life is increasingly shaped by events that took place at a great distance from us. Realist thinkers argued that states are basic actors in international relations and it is anarchical (Pant, 2011). In this anarchical world, states resort to self-help to survive. States rely upon to deploy military capabilities to resolve disputes and antagonisms that were conventional. The immense destructive power of

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THE GEOPOLITICAL IMPORTANCE OF AFGHANISTAN FOR INDIA IN THE 21st CENTURY

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Abstract: *This* review paper explores and overview of the geopolitical importance of Afghanistan for India in the 21st century's geostrategic and geo-economics environment. After the withdrawal of the USA from Afghanistan and recapture of city Kabul by Taliban has deteriorated the strategic and security calculus of south Asia. India is the Neighbouring country of Afghanistan and a true supporter of Afghan-led and Afghan-owned government. This study will also try to suggest the regional and global significance of Afghanistan for peace, security and development.
Keywords: Afghanistan, India, Taliban, Geopolitics, Strategy, Security, Peace

Introduction: Geopolitics is a trinity of the relationship among history, geography and strategy (Sloan, 2017). Geopolitics seeks to analyse the interaction between the spatial setting and political process, i.e., in broader perspective politics, especially international relations as influenced by geographical factors. Therefore, geopolitical studies emphasise how geographical configuration such as location, climate, natural resources, population and physical terrain determines states foreign policy (Grygiel, 2006). From its inception, as a gateway to India, Afghanistan has had great strategic importance. The control of Afghanistan means having strategic control on their trade routes. Conceptually, Afghanistan is a focal point of strategic interest and crossroad for the geopolitical and geoeconomics struggle for power and dominance in the region. Further, it is surrounded by powerful neighbours. It plays a vital role in efficiently connecting the regions and for this reason, remain a geopolitical necessity for any great power (Adamec, 2003). Notably, Afghanistan is the crossroad of routes in Asia. Historically Afghanistan has always been the epicentre of the great game (Bird & Marshall, 2011). Further, its geopolitical location had attracted the regional and international actors to manifest rivalry in this theatre. Earlier British India, later USSR and USA were the part of a great game. These all superpowers had succumbed in a very deteriorated way in front of brave Afghans. It has the fearless and tireless resistance of its brave people. Now is quite interesting to see what will happen because now China is interested in becoming a new player in a never-ending great game in Afghanistan. It is quite interesting that these Afghans have never liked to be conquered. "When everyone is dead the Great Game is finished. Not before." Rudyard Kipling (Edwards, 2003). After fighting the longest-running war in Afghanistan the USA has decided that it will withdraw all remaining troops by the twentieth anniversary of 9/11. The USA withdrawal would be embroiled the regional geopolitical antagonism in Afghanistan (*Remarks by President Biden on the Way Forward in Afghanistan*, 2021). The exit of the USA and entering China into Afghanistan will be beneficial to Pakistan. In this context, it will be a herculean task for Indian policymakers to pursue a strategic interest in Afghanistan including maintaining connectivity up to the Central Asian Republic.

The Geopolitics of Afghanistan: Its regional and global significances

Afghanistan a mountainous landlocked country is, historically, geographically, politically, culturally and strategically a part of central Asia. Owning to religious, Political, geographical features is also a part of South Asia and West Asia (I. Khan, 1998). Its borders are connected with China, Pakistan, Iran, Turkmenistan, Uzbekistan and Tajikistan. Afghanistan has a small stretch of border with India but due to illegal occupation of POK, it's disputed. Geography and history have left

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21वीं सदी में भारत–अमेरिका संबंधों के बदलते आयाम

रविन्द्र कुमार
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सारांश

उन्नीसवीं सदी के अंत से लेकर 21वीं सदी के आरंभ में भारत–अमेरिका संबंधों में बहुत परिवर्तन देखने को मिला है। इक्कीसवीं सदी में वैश्विक चुनौतियों जैसे वैज्ञानिक शोध, तेजी से हो रहे तकनीकी विकास, अर्न्तराष्ट्रीय आर्थिक संबंधों को विकास, पर्यावरण, सुरक्षा आदि अनेक मुद्दो से निपटने के लिए दो देशों के बीच अर्न्तराष्ट्रीय संबंधों में तेजी से परिवर्तन हुए। यही कारण है कि भारत और अमेरिका के मध्य संबंधों में एक नई शुरूआत देखी गई है। भारत एशिया का एक शक्तिशाली देश है। जनसंख्या की दृष्टि से बड़ा देश होने के कारण आज पूरा विश्व भारत को एक बाजार के रूप में देखता है। भारत में तेजी से हो रहे आर्थिक विकास तथा निवश की संभावनाओं के कारण सभी शक्तिशाली देश भारत के साथ खड़े हैं तथा इन देशों का नजरिया भी भारत के प्रति बदला है। बीसवीं सदी के अंत तक जो अमेरिका भारत की अपेक्षा पाकिस्तान के साथ खड़ा दिखाई देता था वही

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इक्कीसवीं सदी में भारत–अमेरिका के मध्य रक्षा सम्बन्धों का विकास

रविन्द्र कुमार*
डॉ. भारती चौहान**

सार

उन्नीसवीं सदी के अंत तक भारत और अमेरिका के मध्य सम्बन्ध परमाणु अप्रसार संधि पर ही केन्द्रित थे परंतु इक्कीसवीं सदी के आरंभ से ही भारत और अमेरिका के मध्य रक्षा क्षेत्र में सम्बन्धों का तेजी से विकास होने लगा। पहले अमेरिकी राष्ट्रपति क्लिंटन और उसके पश्चात् ट्रम्प के भारत की यात्रा से रक्षा सम्बन्धों को नई दिशा मिली। आज भारत अमेरिका से रक्षा उपकरण आयात करने वाला प्रमुख देश है। पिछले दो दशकों में भारत और अमेरिका के मध्य कई रक्षा समझौते हुए जिनका विवेचन इस आलेख में किया गया है।

शब्दकोश: *परमाणु अप्रसार संधि, रक्षा उपकरण आयात, रक्षा क्षेत्र, सामरिक सहयोगी।*

प्रस्तावना

जनसंख्या की दृष्टि से भारत चीन के पश्चात् दूसरा बड़ा देश है जिसके कारण अमेरिका भारत को एक बड़े बाजार के रूप में भी देखता है। इसके अतिरिक्त अपनी आर्थिक जरूरतों एवं चीन की आर्थिक एवं सैन्य ताकत को सन्तुलित करने के लिए भी भारत का महत्व अमेरिका के और अधिक बढ़ गया। आज अमेरिका भारत को दक्षिण एशिया में अपना एक महत्वपूर्ण सामरिक सहयोगी के रूप में देखता है।

भारत और अमेरिका के बीच रक्षा सहयोग में पिछले कुछ वर्षों में तेजी से वृद्धि हुई है और दोनों साझेदारों के बीच सामान्य हितों और बढ़ते विश्वास की गवाही है। भारत और अमेरिका के बीच रक्षा और सुरक्षा सहयोग के पीछे दो मुख्य कारण राजनीतिक समझ और अभिसरण सुरक्षा धारणा की कमी है। रक्षा और सुरक्षा सहयोग में संयुक्त सैन्य–से–सैन्य अभ्यास शामिल हैं, जिसमें सशस्त्र बलों की सभी शाखाओं, सशस्त्र बलों के प्रशिक्षण, हथियारों और उपकरणों की आपूर्ति, उच्च–स्तरीय दौरे, विषय वस्तु विशेषज्ञ एक्सचेंज आदि शामिल हैं। 21 वीं सदी में महत्वपूर्ण भूमिका निभाने वाली क्षेत्रीय और प्रमुख शक्ति के रूप में भारत की बदलती भूमिका के जवाब में रक्षा और सुरक्षा सहयोग विकसित हो रहा है।[1]

इक्कीसवीं सदी में भारत–अमेरिका रक्षा समझौते

इक्कीसवीं सदी के आरंभ से ही भारत और अमेरिका के मध्य रक्षा सम्बन्धों सुदृढ़ होना आरंभ हो गये थे। इससे पूर्व दोनों देशों के मध्य सम्बन्ध मुख्य रूप से परमाणु अप्रसार संधि पर ही केन्द्रित थे। दक्षिण एशिया में शांति स्थापित करने के उद्देश्य से अमेरिकी राष्ट्रपति ने वर्ष 2000 में भारत का दौरा किया और तत्कालीन प्रधानमंत्री अटलबिहारी वाजपेयी और क्लिंटन के मध्य कई समझौतों पर हस्ताक्षर किये गये। बुश प्रशासन द्वारा दिल्ली और वाशिंगटन के बीच रक्षा क्षेत्र में मजबूत करने के प्रयास आरंभ किये गये थे उसे क्लिंटन की इस यात्रा ने गति प्रदान की।[2]

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समसामयिक अन्तर्राष्ट्रीय परिवेश में चीन की हठधर्मिता का वैश्विक प्रभाव

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चीनी क्रान्ति के सम्बन्ध में प्रमुख चिन्तक फ्रीडमैन ने लिखा है कि "साम्यवादी नेतृत्व के एकीकृत्व में राष्ट्रीय शक्ति के रूप में चीनी उदय विष्व इतिहास में सर्वाधिक आश्चर्यजनक घटना है।" जिसने अर्न्तराष्ट्रीय जगत में एक नया मोड़ दिया है।[1] वर्तमान समय में चीन के अभ्युदय से विश्व में एक खोफनाक हलचल पैदा हो गई है खास कर एशिया के देशों पर इसका गहरा प्रभाव पड़ा है। निश्चित रूप से अमेरिका, रूस सहित अनेक एशियाई देशों जिसमें भारत सहित छोटे-बड़े देशों के लिए चीन एक चुनौती बन गया है।

विदित है कि नेपोलियन बोनापार्ट ने सही कहा था कि "चीनी दैत्य सोया हुआ है उसे सोने दो जिस दिन वह जगा तो पूरी दुनियां को हिलाकर रख देगा।" निश्चित रूप से 21वीं सदी में चीन एशिया ही नही वरन् विश्व की सुपर शक्ति के रूप में संघर्षरत है। 19वीं शताब्दी के मध्य में ही देशी शासकों एवं बाहरी हमलावरों के विरूद्ध आवाजें उठी साथ ही सामन्तवाद और साम्राज्यवाद के विरूद्ध संघर्ष छिड़ा यूरोपीय शक्तियों के विरूद्ध लोग सड़कों पर आकर आन्दोलित हुए, वर्ष 1911 के लगभग चीन में पुनरूत्थान एवं भूमि के समान वितरण तथा गणराज्य की स्थापना के नारे गूंजने लगे। बीजिंग से ही क्रान्ति आरम्भ हुई। 1935 में चीन ने जापानी हमले का विरोध किया तत्पश्चात 1 अक्टूबर 1949 को बीजिंग चीनी लोक गणराज्य की राजधानी बनी। अपनी सैन्य एवं आर्थिक शक्ति के रूप में विश्व की सबसे बड़ी सफल फैक्ट्री के रूप में स्थापित होने की कोशिश करता रहा जिसका माल विश्व के तमाम देशों में उपलब्ध हो सकें।[2]

चीन का क्षेत्रफल 9597000 वर्ग कि.मी. जो कि क्षेत्रफल की दृष्टि से विश्व में तीसरा स्थान रखता है। इसकी स्थलीय सीमा 19840 कि.मी. है, जो कि 12 देशों से मिलती है, जिसमें अफगानिस्तान, भूटान, भारत, पाकिस्तान, म्यांमार, नेपाल, लाओस, थाईलैण्ड, मंगोलिया, उत्तरी कोरिया, वियतनाम तथा सोवियत रूस है। वहीं चीन की समुद्री तट 13920 कि.मी. है जो कि उत्तरी कोरिया के तट से दक्षिण में वियतनाम के उत्तर तक फैला है।[3]

अपनी आक्रमक, साम्राज्यवादी एवं विस्तारवादी होने के कारण उसकी इच्छा एशिया में एकाधिकार की रही है। उसके साधन तोड़फोड़ आतंक कपट, चालबाजी और हिंसा है। भारत एशिया में जनसंख्या शक्ति और प्राकृतिक संसाधनों में चीन का प्रतिद्वन्द्वी बनने की क्षमता रखता है, किन्तु उसे यह पसन्द नहीं है। भारत का शक्ति के रूप में उभरना उसका आर्थिक दृष्टि से सम्पन्न होना और विश्व में राजनीतिक सुदृढ़ता प्राप्त करना चीन के लिए ईर्ष्या, द्वेष और वैमनस्यता का प्रमुख कारण रहा है।[4]

अपनी विदेश नीति में भी चीन ने अपने को महाशक्ति के रूप में विश्व रंगमंच पर स्थापित करना, अपनी सैन्य शक्ति में वृद्धि के साथ चीनी सीमाओं का विस्तार करना प्रमुख रहा चीन की बढ़ती हुई शक्ति के परिप्रेक्ष्य में जॉन हे ने कहा था कि "विश्व शान्ति चीन पर निर्भर करती है, जो कोई चीन को समझेगा उसी के हाथ में आगामी पांच शताब्दियों तक विश्व राजनीति की कुंजी होगी।"[5]

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कश्मीर में आंतक का घिनौना चेहरा एवं भारतीय सुरक्षा

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सारांश

जम्मू-कश्मीर में आतंकवाद का ऐसा चेहरा सामने आ रहा है कि जिसका नैतिकता एवं आदर्शों से कोई सरोकार नहीं है इनका न कोई धर्म होता है और न किसी मजहब को मानते, इस घृणित कृत्य से निहत्थे एवं आम लोग मारे जाते है। पाकिस्तान एक ऐसा राष्ट्र है जो जन्म से ही घोर साम्प्रदायिक एवं भारत विरोधी रहा है कश्मीर पर कब्जा आजमाने के लिए वह शुरु से ही कई हथकण्डे अपनाता रहा। अन्ततः उसने आतंक को बढ़ावा देना शुरु किया। आतंकी संगठनों को प्रशिक्षित कर कश्मीर में हिंसा फैलाने का कार्य किया साथ ही आतंकवादी कश्मीर के उन तमाम भोले भाले नवयुवकों को ढाल बनाकर इस कृत्य को बढ़ावा दे रही है। जिससे देश की शान्ति एवं सुरक्षा पर बुरा प्रभाव पड़ रहा है।

भारत सदियों की गुलामी झेलने के पश्चात 15 अगस्त 1947 को आजादी हासिल करने के साथ ही पाकिस्तान ने भी एक इस्लामिक राष्ट्र के रूप में जन्म लिया। भारत अपनी नीति शुरू से ही शान्तिपूर्ण, सहअस्तित्व एवं सभी धर्मो को समान मानते हुए विश्व शान्ति एवं सहयोग के मार्ग पर चलता रहा, किन्तु पाकिस्तान एक ऐसा राष्ट्र जो कि जन्म से ही घोर साम्प्रदायिक एवं भारत विरोधी रहा। यदि पाकिस्तान की करतूतों पर नजर डाले तो वर्ष 1947, 1965, 1971 एवं 1999 में वार बार युद्ध लड़कर समझ चुका है कि भारत की सैन्य शक्ति का मुकाबला नही किया जा सकता इसी कारण आतंकवाद को बढ़ावा दिया।[1]

जम्मू-कश्मीर में पनपा आतंकवाद एक ऐसा घिनौना कार्य है जिसका नैतिकता एवं आदर्शों से कोई सरोकार नही है इनका न कोई धर्म होता है और न किसी मजहब को मानते। इनके कुकृत्य से हजारों निहत्थे निरपराध एवं आम लोग मारे जाते हैं। कश्मीर में आतंकवाद जो कि अरब देशों की उपज है, जो कि मध्य एशिया, अफगानिस्तान तथा पाकिस्तान में अपनी जड़े जमाए हुए है। इन्हीं के बीज अन्य राष्ट्रों में भी पनप रहे हैं। पाकिस्तान को ही देखें तो यहां इस्लामिक पार्टियों में ढेड़ लाख से ऊपर आतंकवादी

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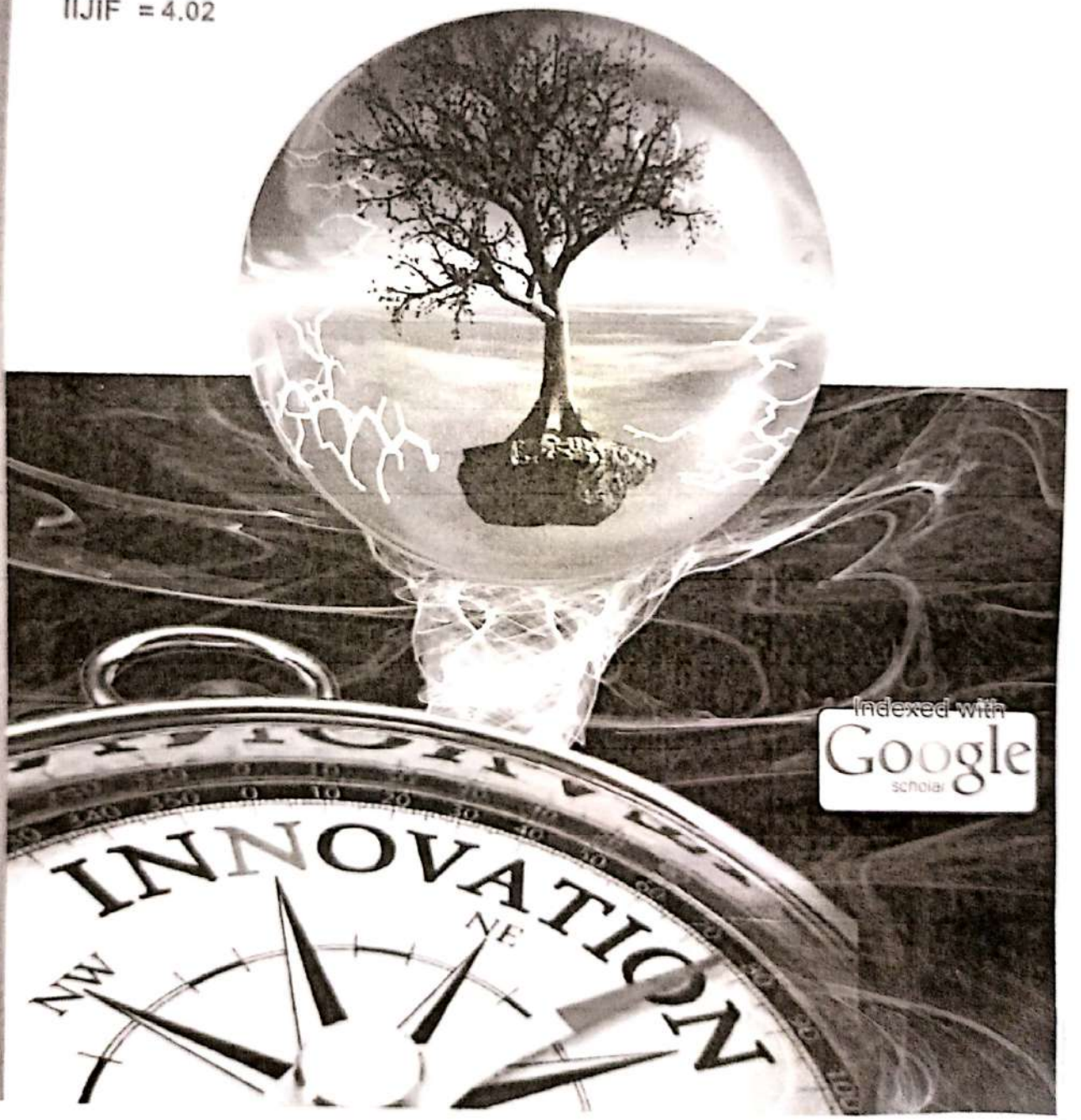

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रक्षा तकनीकी विकास में रडार की भूमिका
Role of Radar in Defense Technological Development

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बिरेन्द्र सिंह जयाड़ा
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रक्षा स्त्रातेजिक एवं
भू–राजनीतिक अध्ययन
विभाग,
हेमवती नन्दन बहुगुणा
गढ़वाल केन्द्रीय विश्वविद्यालय,
श्रीनगर, गढ़वाल, भारत

सारांश

किसी भी राष्ट्र को आत्मनिर्भर होने के साथ सुरक्षा के लिए तत्पर रहना भी आवश्यक है विज्ञान एवं तकनीकी के बदलते स्वरूप को देखते हुए सामरिक क्षेत्र में आक्रमक एवं रचनात्मक संरचना से भी अधिक उसकी रक्षा प्रौद्योगिकी एवं अस्त्र–शस्त्र प्राणियों की क्षमता से आंका जाता है प्रति रक्षा के क्षेत्र में अस्त्र–शस्त्र संबंधी अनुसंधान विकास तथा आधुनिकीकरण तेजी से बढ़ता जा रहा है जिसमें युद्ध पर दूरगामी तथा व्यापक प्रभाव पड़ रहा है प्रथम विश्व युद्ध के समय शीघ्र गामी एवं विश्वरत संचार साधनों में वायुयानों का नियंत्रण एवं निर्देशित करना भी एक प्रमुख समस्या थी वायुयानों का सफल संचालन एवं युद्ध क्षमता में रडार ही एक मात्र ऐसा उपकरण उभर कर सामने आया है जिसमें युद्ध ही नहीं अनेक विपत्तियों से भी बचाव कार्य किया इनमें शत्रु विमानों का पता लगाना, समुद्री युद्ध में शत्रु को एवं पनडुब्बियों को घात लगाकर समुद्र में डुबोने, अंतरिक्ष में नजर रखने, धुंध एवं खराब मौसम, तूफान का पता लगाने, हवाई यातायात तथा परिवहन में सहायता मिलती है भारत भी आत्मनिर्भर बनने के लिए अनेक प्रकार के छोटे किस्म के रडार निर्माण में तन्मयता से विकास कार्य कर रहा है तमाम चुनौतियों के पश्चात आज समय आ गया है कि अपनी सुरक्षा व्यवस्था को अधिक मजबूत बनाने में हमें नए–नए बहुआयामी अनुसंधान कार्य करने होंगे।

It is necessary for any nation to be self-reliant and also to be ready for security, given the changing nature of science and technology, its defense technology and weaponry is more than capable of the strategic and strategic structure in the strategic area. The development and modernization of weapons-related research is increasing rapidly, in which the war is having far-reaching and wide-ranging effects, during the First World War, control and directing of aircraft in fast and reliable communication equipment is also a major problem. In the successful operation and combat capability of the aircraft, only a radar has emerged in which not only the war but also the rescue work from many disasters, in this, the detection of enemy planes in the sea by ambush the enemy and submarines in the sea, Immersion in space tracking mist and bad weather storm detection, helps in air traffic and transport, India also becomes self sufficient in constructing a variety of small types of radars. In order to make our security system more robust, we will have to do new multidisciplinary research.

मुख्य शब्द : रडार, द्वितीय विश्वयुद्ध, वायरलेस तरंगे, अस्त्र–शस्त्र।
Radar, World War II, Wireless Waves, Weapons.

प्रस्तावना

रडार (RADAR) Radio Detecting and Ranging द्वितीय विश्वयुद्ध की क्रांतिकारी खोजों में महत्वपूर्ण उपकरण है। विज्ञान एवं तकनीकी युग में युद्धों पर आज भी इसका काफी प्रभाव पड़ा है। अस्त्र–शस्त्र जहां एक ओर विनाशक होते हैं वही यह एक हथियार के रूप में मूलरूप से आपत्तियों से बचाता है। इसका अविष्कार अमेरिकन वैज्ञानिक ए. ह्यूट टेलर व लियोयंग ने वर्ष 1922 में किया। यह ऐसा उपकरण है, जो रेडियो तरंग के माध्यम से पड़ने वाली गतिशील वस्तु की ऊंचाई, दूरी, गति एवं दिशा को बता देती है। रडार द्वारा छोटी वेब लेन्थ की वायरलेस तरंगे एक विशेष क्षेत्र से टकराकर भेजे जाने वाले स्टेशन पर वापस आ जाती है। इनकी चाल तथा समय द्वारा उत्पन्न दूरी ज्ञात कर ली जाती है। ये तरंगें एक विशेष प्रकार की आवाज भी उत्पन्न करती है।

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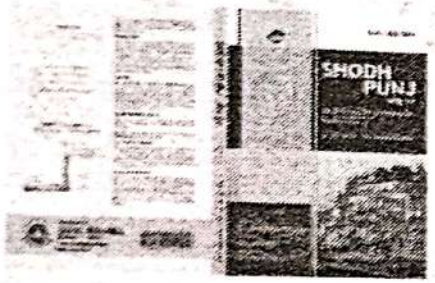

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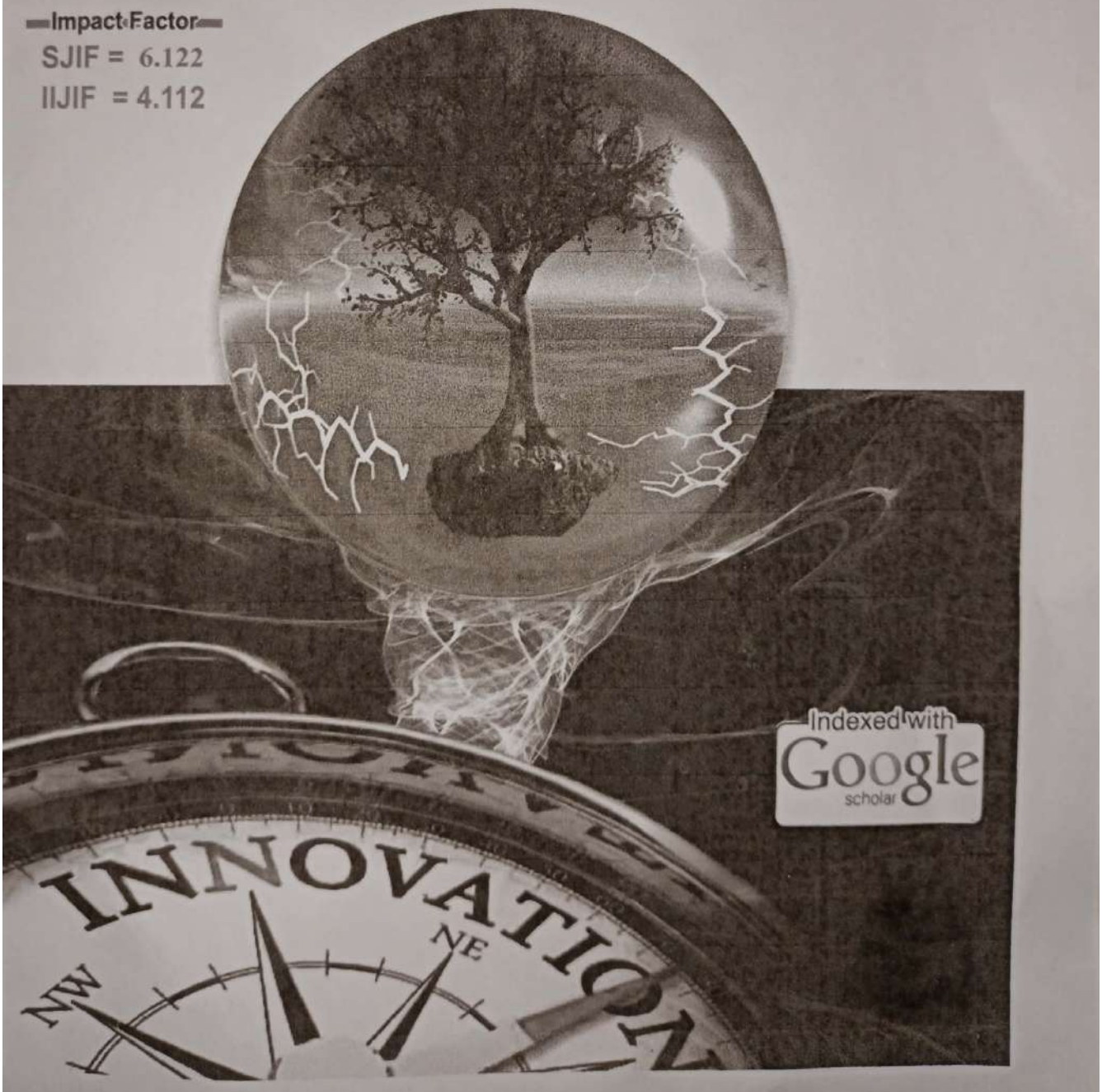

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देवेन्द्र कुमार

शोध छात्र भूगोल विभाग हे०न०ब०गढ़वाल विष्व विद्यालय श्रीनगर उत्तराखंड

बी०पी० नैथानी

प्रो० भूगोल विभाग हे०न०ब०गढ़वाल विष्व विद्यालय श्रीनगर उत्तराखंड

सारांश

पारिस्थितिक पर्यटन और सांस्कृतिक पर्यटन का विकास एवं समस्या में पर्यटक एवं पर्यावरण के बीच में सहसंबंध है पर्यटन के लिए पर्यावरण की आवश्यकता होती है पर्यावरण में कमी के कारण पर्यटन में भी ह्रास होता है उत्तराखंड राज्य के टिहरी जनपद को अध्ययन क्षेत्र के रूप में चुना गया है पारिस्थितिक पर्यटन के लिए यह राज्य का यह एक खूबसूरत क्षेत्र है अध्ययन क्षेत्र के लिए निम्न उद्देश्यों का चुनाव किया गया है अध्यक्ष क्षेत्र में पारिस्थितिक एवं सांस्कृतिक पर्यटन स्थलों की पहचान करना हमारी जनपद में स्थित पर्यटन संबंधित वर्तमान समस्याओं का अध्ययन करना शोध विधि में द्वितीयक स्रोत तो जैसे सरकारी रिपोर्ट साहित्य गुगल अर्थ से छायाचित्र चित्र का संकलन किया गया है। प्राकृतिक और पारिस्थितिक पर्यटन, साहसिक पर्यटन, और सांस्कृतिक पर्यटन में तालाब, झील, पर्वत, ग्लेशियर, धार्मिक स्थल, शैक्षिक स्तर, टैक, नौका बिहार, जंगल वाक आदि का वर्णन किया गया है। प्राकृतिक, खुला वातावरण, धार्मिक परंपराओं, कला संस्कृति, आर्थिक व सामाजिक लाभ हो पारिस्थितिक पर्यटन से स्थानीय लोगों के जीवन में आर्थिक, पर्यावरण सामाजिक एवं सांस्कृतिक प्रभाव पर बदलाव आयेगा। तथा अलग–अलग जीवन शैलियों के लोगों को एक दूसरे से जोड़ने का काम करता है।

मुख्य शब्दः टिहरी गढ़वाल, पारिस्थितिक पर्यटन, सांस्कृतिक पर्यटन, साहसिक पर्यटन, समस्याये।

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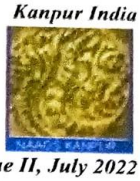

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बी०पी० नैथानी
प्रो० भूगोल विभाग हे०न०ब०गढ़वाल विष्व विद्यालय श्रीनगर उत्तराखंड

कोविड–19 वायरस के विस्फोट ने भारत सहित संपूर्ण विष्व में वैष्विक स्वास्थ्य का संकट खड़ा कर दिया है। जिसके चलते सामान्य वर्ग से लेकर उच्च वर्ग के सभी व्यक्तियों को खासी दिक्कतों का सामना करना पड़ा है। इसके प्रसार का माध्यम व्यक्ति से व्यक्ति को संचरण है, जिसके चलते सामाजिक दूरी का पालन इसके रोकथाम का एकमात्र प्रभावी वह कारगर उपाय है। किंतु इस सामाजिक दूरी ने संपूर्ण समाज के कार्यशैली, दिन–प्रतिदिन के कार्यों को रोकने का भी काम किया है। जिसके चलते आर्थिक संस्थागत, व व्यक्तिगत व सामाजिक विकास भी अवरुद्ध हुआ है। जिसमें बेरोजगारी आजीविका संकट शिक्षा स्वास्थ्य पोषण जैसे आवश्यक कारकों पर नकारात्मक प्रभाव डाला है। प्रस्तुत अध्ययन के माध्यम से तात्कालिक समय में व्यक्तियों समुदाय व सरकार के द्वारा जो आवश्यक कदम इस भयानक बीमारी के रोकथाम हेतु किये गये थे उनके अध्ययन का विभिन्न मापदंडों पर परीक्षण व निष्कर्ष रूप में किया गया है।

कीवर्ड – कोरोना विषाणु, मानव स्वास्थय, तालाबन्दी, स्वच्छता।

प्रस्तावना

कोरोना विषाणु की उत्पत्ति चीन के वुहान शहर से दिसंबर 2019 में निमोनिया जैसी बीमारियों के लक्षण वाले रोग की तरह सामने आयी। ऐसा माना जाता है कि चीन की सीफूड नामक बाजार से चमगादड़ के सूप पीने से यह विषाणु मानव शरीर में पहुंचा और संक्रमित मानव से अन्य लोगों में यह वायरस तेजी से फैला। कोरोना संक्रमण के प्रमुख लक्षणों में सूखी खांसी, बुखार गले में दर्द, कमजोरी चक्कर आना प्रमुख है। यह बीमारी संक्रमित व्यक्ति से दूसरे व्यक्ति में फैलती है।

कोरोना विषाणु मुख्यतः मानव शरीर की श्वसन प्रणाली को प्रभावित करता है। यह छोटी उम्र के बच्चों (10 साल से कम) तथा बुजुर्गों (60 साल से अधिक) को सबसे ज्यादा प्रभावित करता है। विश्व स्वास्थ्य संगठन (डब्ल्यू०एच०ओ०) की एक अध्ययन के अनुसार 6% लोग इस वायरस के कारण गंभीर रूप से बीमार हुए. इनमें फेफड़े खराब होना, सेप्टिक शॉक ऑर्गन खराब होना प्रमुख है। 14% लोगों में संक्रमण के लक्षण देखे गए इन में सांस लेने की दिक्कत हो रही थी। लगभग 80% लोगों में संक्रमण के मामूली लक्षण दिखे जैसे बुखार खांसी आदि। न्यूयॉर्क सिटी हेल्थ द्वारा 13 मई 2020 तक उपलब्ध आंकड़ों के अनुसार महिलाओं की अपेक्षा पुरुषों में कोरोना वायरस के कारण संक्रमण एवं मृत्युदर अधिक है। कोरोना वैश्विक संक्रमण की बात करें तो लगभग हर देश इस बीमारी से जूझ रहा है। चीन के बाद, अमेरिका,

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UGC Care Listed Journal

GEOGRAPHICAL STUDY OF MIGRATION IN TEHRI GARHWAL DISTRICT, UTTARAKHAND

Chet Ram, Devendra Kumar and B.P. Naithani

Abstract

Migration refers to the movement of people from one place to another, often across national or regional borders. This movement can be voluntary or involuntary, and can be driven by a variety of factors, including economic, social, political, and environmental reasons. Migration can take many forms, including temporary or permanent migration, internal or international migration, forced or voluntary migration, and economic or refugee migration. In 2020, there were a total of 281 million international migrants globally, which was 3.6% of the world population. India had 17.5 million international migrants and it received 78.61 billion USD remittances in 2019. Globally, out of a total of 281 million migrants in 2020, 146 million are men, 135 million are women, 169 million are migrant workers, in addition there are 3900 missing migrants. This research paper is based on the causes and consequences of migration in Tehri Garhwal district of Uttarakhand state. The main objectives of this research paper are to study the present status of migration, causes and consequences of migration and to suggest measures to reduce migration in the Tehri district. This research paper is completely based on secondary data. Secondary data has been obtained from Uttarakhand Government's Rural Development and Migration Commission report 2019-2020 and District Census Handbook 2011. After collection of data, the data has been analyzed through maps and diagrams. Data analysis has been done by Microsoft excel software and mapping by Arc GIS and Q-GIS software. The study may have identified various factors that push people to migrate from Tehri Garhwal district.

Introduction

Migration refers to the movement of people from one place to another, often across national or regional borders. This movement can be voluntary or involuntary, and can be driven by a variety of factors, including economic, social, political, and environmental reasons. Migration can take many forms, including temporary or permanent migration, internal or international migration, forced or voluntary migration, and economic or refugee migration. People may migrate individually

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ORIGINAL ARTICLE

Micro-watershed Planning using Prioritisation Approach Integrated with Geospatial Techniques and Compromise Programming: A Case Study of Bacchanshiv Gad (Alaknanda River), India

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ABSTRACT

A micro-watershed is the smallest hydrological unit with a unique type of common-pool resource, defined by hydrological linkages and requiring coordinated use of natural resources by all users for optimal management. However, the watersheds in the central Himalayan region are particularly vulnerable to land degradation since they are subject to various fluvial and denudation processes. As a result, the present study focused on the Bacchanshiv Gad watershed in the subtropical zone, where soil erosion is more prevalent due to various hydro-geomorphological causes. The analysis considered fourteen different areal, linear, shape, and landscape morphometric parameters by integrating spatial and compromise statistical programming techniques to prioritize 8 micro-watersheds. Moreover, the study gives comprehensive insight about the current land use land cover spatial distribution, lithological and pedan characteristics of the watershed that play a significant role in taking appropriate land and water conservation measures to prevent further soil degradation.

INTRODUCTION

In consideration of the biotic and abiotic resources-related issues, micro-watershed planning is the utmost appropriate practice to be focused upon in the contemporary world and an inevitable for conserving ecological resources (Rao & Pant, 2001; Wakeel et al., 2005; Chauhan et al., 2016). Micro-watershed planning involves harmonizing the use of natural resources and maintaining a balance between the resource developments to protect the resources for future utilization and, consequently, increase the welfare of the people (Sarkar et al., 2006; Gera et al., 2010). A methodological approach of allocating the ranks to the watersheds to their vulnerability and potentiality has been found effective for their successful management measures based on various geological parameters, i.e. morphometric attributes.

Watershed ranking has been proved as a decisive principle that prioritizes the sub-watersheds keeping in view their need for effective and productive watershed protection. Providentially, numerous novel works pertains to this issue of prioritization of watersheds has been attempted using various well-known techniques, Multi-criteria decision analysis (MCDA) in conjunction with different weight deriving methods of sub-watersheds in multiple scales (Nitheshnirmal et al., 2019; Nunchhani et al., 2020); principal component analysis; (Singh and Singh, 2018; Malik et al., 2019; Kumar et al., 2021) weighted sum analysis (WSA); (Kadam et al., 2019; Siddiqui et al., 2020); sub-watershed priority tool (SWPT) integrated with WSA method (Rahmati et al., 2019).

In addition to the aforementioned approaches, the entropy method in conjunction with compromise programming (CP) is also the most effective approach for sub-watershed prioritization (Arabameri et al., 2018). Raju et al. (2017) implemented the CP technique to rank the global climate models, which evaluates climatic variable simulation. Díaz-Balteiro et al., (2011) aggregated various socio-economic indicators into a composite index using CP to provide weightage to the sustainability of European paper industries. Li et al., (2022) carried out the CP method to expound the methodology for allocating water and land resources sustaining ecological balance. Fattahi and Fayyaz (2010) attempted the CP approach to refine urban water management by elucidating the effective solution to eradicate the problems of leakage of water, level of social satisfaction, and cost of water distribution. The geospatial techniques include the tools contributing to the geographic mapping are paramount importance in assessing morphometric parameters (Chandniha and Kansal, 2017).

According to Batar et al. (2017), topo-hydrologic and geo-morphometric parameters directly affect selecting sites and implementing land and water management policies in sub-watersheds at the micro-level. These factors provide insight into the evolution of catchments and their function in drainage morphometry (Rahmati et al., 2019; Sharma and Mahajan, 2020). However, topo-hydrological parameters like the stream frequency (Fs), compactness constant (Cc), constant of channel maintenance (C), bifurcation ratio (Rb), drainage density (D), elongation ratio (Re), circularity ratio (Rc), form factor (Rf), drainage texture ratio (Rt), stream transport index (STI), stream power index (SPI), topographic wetness index (TWI), hypsometric integral (HI) and dissection index (DI) have been considered for the

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An Integrated Study of Natural Springs to sustain water security: Case Study of three villages from a Himalayan State of India

Un estudio integrado de manantiales naturales para mantener la seguridad hídrica: estudio de caso de tres pueblos de un estado del Himalaya de la India

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ABSTRACT

Equitable access to water, whether it is quantity or quality, is one of the fundamental rights. It facilitates economic development, gender equality and good human health. But in the last few decades, lack of potable water has caused illness and resulting millions of deaths. In Himalayan Region, springs are the basic water source which fulfills the needs of rural population. The point at which the groundwater emerges over the earth surface and flows naturally is called spring. Drying up of these springs, due to climate change and biophysical landscape change, is not only causing problem to human health, impeding gender equality but also causing nearby bio diversity to lose resilience. Therefore, a basic understanding of springs is required for its further studies and to maintain water security. This present work is focused on the initial steps of Spring Sanctuary development. The present outline emphasized on the spring mapping and has prepared a social database of springs of three villages of Saurakhaal nyay panchayat of jakholi block, Rudraprayag, Uttarakhand. The status of the springs has been assessed by monitoring their discharge data for eight months (Nov, 2020-June, 2021). Also, the endangered and vulnerable springs of the study area has been identified by scoring them on the basis of critical issues.

Key Words: Springs, Climate Change, Bio-Physical landscape, Spring Sanctuary, endangered and vulnerable springs.

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"वर्षा जल संचयन के पारंपरिक पद्धतियों की समीक्षा": भारत के संदर्भ में

पवन सिंह
शोध छात्र भूगोल विभाग हे.न.ब.गढ़वाल विश्व विद्यालय श्रीनगर उत्तराखण्ड

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सारांश -
पारंपरिक जल संचयन की तकनीकी व प्रणालियाँ सदियों से भारतीय जनसंख्या की आवश्यकताओं को पूर्ण करती रही है। जल संचयन बहते जल को एकत्रित और संग्रहित करने की प्रक्रिया है, जो कि अलग-अलग भागों में भिन्न-भिन्न है। भारत में वर्षा जल संचयन की प्रणालियों के प्रकारों में मुख्य रूप से उत्तराखंड के नौलें ,धारें, पंधेरे, उत्तर प्रदेश के पड़ सिंचाई, मध्य प्रदेश का कटास, उड़ीसा का बिंदास, गुजरात का नाला बंध, राजस्थान के बावड़ी, हिमाचल का गुल, जम्मू कश्मीर व लद्दाख का झिंग व चश्मा, मेघालय का बांस, अरुणाचल प्रदेश का अपतानी व ढोंग, असम के बंद, नागालैंड का जाड़ों व जैकबेल, सिक्किम का धारा विकास सम्मिलित हैं जो कि पारंपरिक संरचनात्मक सरलता एवं उच्च तकनीकी प्रणालियों को दर्शाता है। भारत के यह सभी जल स्तंभ अलग-अलग समयांतराल में निर्मित हुए हैं। जल की उपलब्धता एवं पूर्ति हेतु अलग-अलग जल संचयन की तकनीकियाँ हैं। जिसमें प्रमुख रूप से प्राचीन काल में निर्मित मंदिरों के समीप ही जल के स्रोत का होना है। वर्तमान में, प्राचीन पारंपरिक ज्ञान को सीखने व समझने की आवश्यकता है। ताकि जल संरक्षण की समस्याओं से निपटने हेतु इन स्रोत का प्राचीन पारंपरिक ज्ञान को आधुनिक समाज में लागू किया जा सके। जो कि पारिस्थितिक रूप से सुरक्षित एवं समृद्ध प्रणाली है। भारत में घटते भू-जल स्तर को पुनर्जीवित करने में सहयोगी विधियाँ कम लागत वाली है। वर्तमान आधुनिक समाज की नवीन तकनीकियों एवं पारंपरिक ज्ञान के सामूहिक दृष्टिकोण से जल स्रोतों का अध्ययन करने की आवश्यकता है। इसका मुख्य उद्देश्य सिंचाई एवं पीने योग्य जल का संरक्षण है, जो वर्तमान में सबसे गंभीर समस्या बनी हुई है।

मुख्य शब्द – जल संचयन, पारंपरिक, प्रणालियां, वर्षा, पेयजल , सिंचाई।

प्रस्तावना

जीवन की उत्पत्ति के प्रारंभिक चरण से जल की महत्ता रही है। जल के बिना जीवन की कल्पना भी नहीं की जा सकती, परंतु फिर भी हम में से कुछ लोग यह सोचते और समझते हैं, की जल एक असीमित संसाधन है परंतु वास्तविकता यह है की जल एक सीमित संसाधन है, जो जनसंख्या के बढ़ते हुए क्रम में मानवीय एवं प्राकृतिक संसाधनों का दोहन तेजी से करने पर इसकी गुणवत्ता एवं उपयोगिता मात्रा में

Role of Women in Conservation of Sacred Springs & Cultural Dimensions – A Case Study of Nari Village of Rudraprayag District, Uttarakhand

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Abstract: *The communities of the Himalayas have an absolute cultural relationship with springs. This study is focused on the contribution of women in the conservation of the sacred springs and on understanding the cultural dimensions of the relation between springs and communities of the Nari village of Rudraprayag district. The primary data is collected with an interview of 70 people with a pretested mix-ended questionnaire. The secondary data is collected from local representatives. It is found that the water of sacred springs is used for traditional practices such as Dhara Poojan, Dev Poojan, Marriages, etc. The women of the village are working to conserve springs through Mahila Mangal Dal, Swachh Bharat Mission & MGNREGA.*

Key Words: *Sacred Springs, Culture, Indian Himalayan Region, Uttarakhand, Women.*

1. INTRODUCTION

Himalaya is acknowledged as a cryogenic water pole of Asia as it is a home to many freshwater sources such as glaciers, glacial-fed and spring-fed rivers, lakes, springs, etc. (Gergan 2002) It beholds the cultural fragrance of various communities, societies, religions, etc. (Prasad and Sharma 2019).

Uttarakhand is acknowledged as the 'land of Gods' (Devbhoomi). It is also known as a cradle of natural resources and spirituality which attracts lots of tourists and saints as well. A slight variation in the dialects of the communities can be observed every few kilometers which shows the richness and diversity in culture. (Acharya 2011)

As per scientific interpretation, a spring is a place on the surface of the earth from where groundwater gets discharged and becomes surface water. Sacred springs play a vital role in the cultural practices and customs of communities. Communities and springs have an absolute interdependency on each other. Communities of Rudraprayag district practice various rituals such as Dev Poojan, Dhara Poojan, etc. As per UNDP's estimation, there are 2.6 lakh springs found in Uttarakhand only which provide drinking water to more than 90%. These springs are the primary source of drinking water in many villages. (Goswami 2018) People have been fetching drinking water from natural springs in mountainous regions for thousands of years ago.

The major environmental challenge in the present era is water scarcity, many villages of Uttarakhand have been facing the drying up of natural springs. These springs are drying up due to climate change, degradation of forests, erratic rainfall patterns, land-use change, unscientific constructions, etc. (Gupta et al. 2018). In the rural areas of the Indian Himalayan Region (IHR), women have been making a remarkable contribution by taking steps for conservation of natural resources. Women have to deal with most of the water-related issues as they are the first ones to be in contact with water because they use water for drinking, washing dishes-cloths, irrigation, and other household works, etc. Therefore, the role of women in the conservation of sacred springs becomes more significant. (IWMI 2006)

2. STUDY AREA

The Nari Village is located in the Rudraprayag District of Uttarakhand state. (Figure. 1) This village is selected to understand the cultural relationship between sacred

BIOMEDICAL WASTE MANAGEMENT IN PUBLIC AND PRIVATE HOSPITALS OFDELHI- A COMPARATIVE ANALYSIS*

BY

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ABSTRACT

The management of biomedical waste is a big challenge due to its hazardous nature. With the betterment of the health facilities and improved technologies, the generation of medical waste has also increased posing serious health problems to the exposed population if not managed efficaciously. Thestudy determined the medical waste management practices adopted by selected 5 major public and 5 private hospitals of Delhi. From different hospitals data were collected through questionnaires, crucialsite observation, field visits, and interactive interview sessions with the person in charge. Thecollection of data leads to comparison among different parameters like waste generation, segregation,methods of disposal, etc. were done between public and private hospitals by using Microsoft excel. The computed percentage of general and other hazardous waste such as infectious, chemical, and human anatomical wastes, etc. generated by the private hospital is 55.89% and 44.11% respectively. Apart from that public hospitals generate 56.33% general waste and 43.67% other hazardous waste. The segregation process of medical waste in private hospitals is far better than in public hospitals. Still, we found that private hospitals are lacking in facilities for waste treatment and disposal. It is conluded that either its private hospital or public hospital, both require improvement in some way orthe other in biomedical waste management. There is a need for capacity building at all levels, as wellas the formulation of policies, to strengthen uniform and effective waste management practices.

Keywords: Biomedical waste, Hazardous, Public hospital, Private hospital, Disposal.

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INTRODUCTION

"Biomedical waste" is the type of waste, which is generated from the hospitals and research institutions during the process of diagnosis, treatment, or immunization of humans being and animals. (schedule1,biomedical waste rules, 2016). Bio-medical waste is categorized as Hazardous and non-hazardous. Around 70 and 90% of total waste produced by hospitals is non-hazardous and the remaining 25% ofwaste is hazardous., (**Awodele et al.,2016**). Due to the high volume of sharp, hazardous chemicals, pharmaceuticals, and radioactive waste in medical waste, it requires urgent attention to be handled carefully., (**Mato & Kaseva, 1999**). The hazardous waste requires proper disposal as it may lead to

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A Comparative Study of Municipal Solid Waste Management in ThreeMajor Cities of Uttarakhand, India

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Abstract: Waste management is a big challenge in emerging countries like India. The purpose of this study is to determine the current condition of waste management in three main cities of Uttarakhand, namely Dehradun, Haridwar, and Rishikesh. Based on municipal solid waste generation,transportation, and disposal in these three important municipalities, a comparative study is conducted.During the current study, it was estimated that Dehradun generates about 350 metric tonnes of waste,Haridwar produces 126 metric tonnes of waste, and Rishikesh produces 60 metric tonnes of waste. After the collection of data, correlation is computed between the population and the waste generationin the three cities and it was concluded that the city with a large population generates maximum wasteand poor waste management is found. Among the three cities Dehradun is found to worst in waste management and Rishikesh is much better in managing and handling the waste. There is scope of lot of improvement in all the three cities when it comes to management of waste. The open dumping ground is impacting the people and the environment near the site, thus all three municipalities are having trouble disposing of garbage.

Keywords: Waste Management, Dehradun, Haridwar, Rishikesh, Correlation

Introduction

The term "municipal solid waste" refers to a mixture of household and commercial garbage created bythe public at large (Rajkumar *et* al., 2010). Degradable (paper, textiles, food waste, straw, and yard waste), partially degradable (wood, disposable napkins, and sludge), and non-degradable (leather, plastics, rubbers, metals, glass, ash from fuel-burning like coal, briquettes, or woods, dust, and electronic waste) materials constitute municipal solid waste (Jha *et* al., 2011). India is estimated to produce around 62 million tonnes of trash every year, with solid waste averaging 0.4 kg per capita perday (Ramachandran M., 2014). The composition and quantity of MSW were

created to serve as the foundation for planning, designing, and operating the management system. When compared to MSW in Western countries, MSW in India differs significantly in terms of composition and hazardous nature (Gupta S, *et* al., 1998)

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AN IMPACT OF FLOOD ON SOCIO-ECONOMIC STATUS – A CASE STUDY OF SAMPLE VILLAGES IN JOSHIMATH BLOCK, UTTARAKHAND

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Shilpi Yadav
Chet Ram

Abstract

Natural hazards have caused a great deal of trouble for mankind throughout history, and their effect on national economies has also been noted. Landslides, cloudbursts, earthquakes, and floods are all common natural hazards in the Himalayan region. Floods have proven to be the most destructive of them all. Floods have had a major effect on the socio-economic lives of thosewho live near river basins or low-lying areas. The study aims to see how floods affect people's socio-economic lives in sampled villages in Uttarakhand's Chamoli district. The study is basedon categorical (qualitative) and computable (quantitative) data which is collected from 3 sampled villages (Raini, Tapovan, Payya Chormi). The qualitative data is collected through in-depth interviews with local people during the post-flood period, and the quantitative data is collected through random sampling of the population in selected villages. Following data collection, MS Excel was used to analyze the data, and Arc-GIS was used to create the study map. The study's findings show that the recent flash flood in Chamoli district harmed the villages' social and economic conditions. 46% of people say floods are quite frequent in the sampled villages which in turn impacts their employment. 54% of people in the sampled village suffered from unemployment. It is also evident from the results that floods have caused infrastructure damage (84%) which in turn had impacted the children's education as well. To deal with such issues we should promote group engagement in disaster coping strategies by increasing individual participation through seminars about coping methods and also provision of emergency food, water, drugs, and shelter for those affected.

Keywords: Natural Hazardous, Socio-economic, Flood, Chamoli, Arc-GIS

Role of Women in Conservation of Sacred Springs & Cultural Dimensions – A Case Study of Nari Village of Rudraprayag District, Uttarakhand

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Abstract: *The communities of the Himalayas have an absolute cultural relationship with springs. This study is focused on the contribution of women in the conservation of the sacred springs and on understanding the cultural dimensions of the relation between springs and communities of the Nari village of Rudraprayag district. The primary data is collected with an interview of 70 people with a pretested mix-ended questionnaire. The secondary data is collected from local representatives. It is found that the water of sacred springs is used for traditional practices such as Dhara Poojan, Dev Poojan, Marriages, etc. The women of the village are working to conserve springs through Mahila Mangal Dal, Swachh Bharat Mission & MGNREGA.*

Key Words: *Sacred Springs, Culture, Indian Himalayan Region, Uttarakhand, Women.*

1. INTRODUCTION

Himalaya is acknowledged as a cryogenic water pole of Asia as it is a home to many freshwater sources such as glaciers, glacial-fed and spring-fed rivers, lakes, springs, etc. (Gergan 2002) It beholds the cultural fragrance of various communities, societies, religions, etc. (Prasad and Sharma 2019).

Uttarakhand is acknowledged as the 'land of Gods' (Devbhoomi). It is also known as a cradle of natural resources and spirituality which attracts lots of tourists and saints as well. A slight variation in the dialects of the communities can be observed every few kilometers which shows the richness and diversity in culture. (Acharya 2011)

As per scientific interpretation, a spring is a place on the surface of the earth from where groundwater gets discharged and becomes surface water. Sacred springs play a vital role in the cultural practices and customs of communities. Communities and springs have an absolute interdependency on each other. Communities of Rudraprayag district practice various rituals such as Dev Poojan, Dhara Poojan, etc. As per UNDP's estimation, there are 2.6 lakh springs found in Uttarakhand only which provide drinking water to more than 90%. These springs are the primary source of drinking water in many villages. (Goswami 2018) People have been fetching drinking water from natural springs in mountainous regions for thousands of years ago.

The major environmental challenge in the present era is water scarcity, many villages of Uttarakhand have been facing the drying up of natural springs. These springs are drying up due to climate change, degradation of forests, erratic rainfall patterns, land-use change, unscientific constructions, etc. (Gupta et al. 2018). In the rural areas of the Indian Himalayan Region (IHR), women have been making a remarkable contribution by taking steps for conservation of natural resources. Women have to deal with most of the water-related issues as they are the first ones to be in contact with water because they use water for drinking, washing dishes-cloths, irrigation, and other household works, etc. Therefore, the role of women in the conservation of sacred springs becomes more significant. (IWMI 2006)

2. STUDY AREA

The Nari Village is located in the Rudraprayag District of Uttarakhand state. (Figure. 1) This village is selected to understand the cultural relationship between sacred

The Geographical Study of Impact of Covid-19 on the Education Sector: A Case Study ofClement Town

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Abstract

The sudden outbreak of Covid-19 led the world, to a curfew-like lockdown. The rising Death rateput fear in the mindset of the people which influenced physical distancing. The Emergent scenario of social distancing led to the transformation of On-Site Teaching-Learning services into On-Line services. However, the transformation kept the world going on but it brings a number of hurdles. In this case study, of Clement Town, the study presents that teachers & students have faced multiple challenges in the On-Line Teaching-Learning system. The quality of On-Line Teaching-Learning System is deeply affected by its various variables. Along with the pandemic, online teaching services are boosted.

Keywords: Covid-19, Education, Students, Teachers, On-Site, On-line, Teaching-Learning

Introduction

The impact of pandemic Covid – 19 has taken over almost all continents in the world. The first case was identified in Wuhan, China, in December 2019. The disease has since spread worldwide, leading to an ongoing pandemic. The first case of COVID-19 in India, which originated from China, was reported on 30 January 2020. The outbreak has been declaredan epidemic in more than a dozen states and union territories, where provisions of the Epidemic Diseases Act, of 1897 have been invoked, leading to the temporary closure of educational and commercial establishments. All tourist visas were suspended in March, as many of the earliest confirmed cases were individuals who had traveled from foreign countries.

Covid - 19 has put uncertain challenges for students but opened up other un-proposed opportunities as well. The rapid spread of virus led the whole world towards a deterministic emergent curfew-like lockdown which dynamically promoted possibilistic Virtual or Online education system over Physically influenced On-Site education system. These sudden variables put a number of complexities & challenges in front of students as well as teachers.

According to UNESCO, the COVID-19 pandemic has interrupted classroom learning for at least 9 out of 10 students worldwide, and about half of the students worldwide have no access to online teaching (826 million learners worldwide have no access to a computer) (UNESCO 2020) This study focuses on the impact of Covid-19 on the quality of Education. Such as Zoom, Google Meetings etc. have become a pioneer in online learning & teachings which encompassesthe possibilities in future education system.

Study Area

Clement town is a Category-II cantonment, and deemed municipality administered by a cantonment board under the Ministry of Defense. It is located in district of Dehradun, Uttarakhand. The Clement Town city is divided into 7 wards for which elections are held every 5 years.

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Awareness Attitude and Utilization of Universal Immunization Program with Reference to Mission *Indradhanush* in Rudraprayag Town of Uttarakhand

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Abstract

The Universal Immunization Program (UIP) is one of the largest health programs in the world which aims to provide vaccination to each infant and pregnant woman every year across the country, yet the number of children dying due to vaccine-preventable diseases (VPD) is 5 lakh. The vision of Mission Indradhanush is to achieve more than 90% full immunization coverage by the year 2020. The objectives of the present study are to assess the awareness of the mothers about Mission Indradhanush; their knowledge, attitude and utilization of childhood immunization program and to analyse the association between knowledge and utilization of immunization program with selected socio-economic and demographic factors. A cross-sectional study was conducted from April to May 2019 among mothers having children of 12-23 months of age in the Rudraprayag Nagar Palika Parishad. The average age of the selected children was 17.28±3.23 months; while the average age of respondents (mothers) was 26.81± 2.67 years. The 98% of the respondents were literate and 97% mothers believed that vaccination is compulsory for their children and 81% of them believed that vaccination improved their child's immunity, 84% of the respondents had Mother and Child Protection Card with them. A total of 72 % of respondents have heard about Mission Indradhanush and 76% of children were found fully immunized.

Keywords: Attitude, Immunization, Mission *Indradhanush*, Universal Immunization Program.

1. INTRODUCTION

Development of health infrastructure is given a major priority in developmental policies around the world. Children are the future of any nation and to secure them against VPD by introducing immunization programs is an important step for safeguarding their childhood. Immunization also helps in reducing the child mortality rate. Therefore, the Government of India(GOI)launched various immunization programs in order to make sure that not a single child will remain deprived of immunization against vaccine-preventable childhood diseases.

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Short Communication

The Distribution Pattern and Existing Disparities in Public Health Care Centres in Rudraprayag District of Uttarakhand, India

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ABSTRACT

Distribution pattern of existing health centre is an important aspect of health care delivery system. In mountainous region specifically in developing countries, it also influence the decision making process of individuals at times of need of such facilities. The present study aims to analyse the spatial distribution pattern and disparity of health care centres in Rudraprayag district of Uttarakhand by applying statistical techniques such as Location Quotient, Lorenz Curve and Gini Index. Though the health care facilities shows satisfactory situation in case of distribution pattern of public health care centres at district level, but while analysing these facilities at block level, the results reveals that there is significant inequality in the distribution pattern of both Primary Health Centres as well as Sub-Centres. The study is able to provide help to people and policy makers to estimate the health care facility needs and mark the areas facing comparatively high population pressure in terms of ratio of health centres to population.

Keywords: Spatial Disparity, Public Health Care Centres, Primary Health Centres, Sub-Centres, Inequalities

INTRODUCTION

Human health is an essential and integral part of a Nation's strength and prosperity. Provision for basic medical facilities has been one of the main objectives of all the developmental strategies. With the rapid increase in population as well as rising standard of living, it becomes a difficult task for every individual to achieve a better health. If health of individuals is to be improved, particularly in developing countries health care service system must be capable of delivering effective health care services and members of the society must use these services. [1]

Health care is a multitude of services available to individuals or community by the health professionals for promoting, restoring and maintaining health. Healthcare delivery system refer to the totality of resources that a population or society distributes in the organization and delivery of health services. [2]

Health care system implies the organization of the people (i.e. doctors, nurses etc.), institution (hospitals, PHC, CHC etc.) and resources to deliver health care services to meet the health needs of target population. Healthcare in India is handicapped because it has to face serious crises in cost, quality of care and equitable distribution of mode and standards of service to the population as a whole. Spatial analysis approach in geography concerns itself with the variation in the localisation and distribution of a significant phenomenon or a group of phenomena over geographical space in order to understand the inequalities in it. An important issue of

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"CONTRIBUTION OF AGRICULTURE AND HORTICULTURE IN RURAL DEVELOPMENT OF KULLU BLOCK (KULLU DISTRICT, HIMACHAL PRADESH) AND RELATED CHALLENGES"

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ABSTRACT

Agriculture and horticulture are the backbone of the economy of Himachal Pradesh and Kullu district. The climate of Himachal Pradesh is suitable for agriculture and horticulture due to which a large number of agriculture and horticulture crops like food crops, fruit crops, flowers, mushrooms, vegetables and medicinal plants are successfully grown here. The fruits of different varieties which are found in subtropical and temperate climate can also be grown in Himachal Pradesh and help in the economic development of rural areas by generating employment and revenue for the rural population. The objectives of this study is to identify the agriculture and horticulture production and the contribution of agriculture and horticulture in rural development and the challenges related to agriculture and horticulture in the study area. This study is based on both primary and secondary data. Secondary data is obtained from various government departments and reports. The collection of Primary data is done through schedule, interviews, personal observation and field visit. This can be concluded from the study that, almost the entire rural population in the study area is dependent on agriculture and horticulture but they neither get the fair price of their crops nor get various infrastructural facilities and also have to face many physical and socio-economic challenges

Keywords – Agriculture, Challenges, Contribution, Horticulture, Rural development.

Introduction

Agriculture and horticulture are the backbone of the Indian economy and Himachal Pradesh. Indian agriculture employs a very large workforce which was 42 percent in 2019 while it accounts for 16.5 percent in gross domestic product (GDP). India is still a country with a rural economy with about 66 percent of the country's population living in rural areas and agriculture still the mainstay of this rural population. Agriculture is most

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'GEOGRAPHICAL STUDY OF THE PROBLEMS OF SLUM DWELLERS IN KULLU DISTRICT OF HIMACHAL PRADESH'

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ABSTRACT

The appearance of slums may be seen as a derivative of urbanization in developing countries. Cities are the places where fundamental changes occur and lead to socio-economic development and modernization. The higher level of basic amenities is available along with more employment opportunities in urban areas. Rural population migrates to urban areas in search of these basic amenities and employment. Due to lack of required skills migrants engaged in low income works, due to which neither they are able to nurture their family nor get the urban basic amenities. So they are forced live in the slums. This research paper is based on a study of the problems of slum dwellers in Kullu district of Himachal Pradesh. Out of the total 150 families of these settlements, 60 families have been selected by the simple random sampling method. This study is fully based on primary data. This study has concluded that, these slums completely lack of all basic amenities like housing, drinking water, sanitation, education, health, electricity and cooking fuel.

Keywords : Slum settlements, basic amenities, Kullu district, problems

Introduction

Any predominantly residential area where the dwelling by reason of dilapidation, overcrowding, faulty arrangement of design, lack of ventilation, light and sanitary facilities or any combination of factors are detrimental to safety, health and morals is called to be a slum **(USA Housing act, 1949).** In the last few decades, urbanization has increased in the developing countries of the world creating a high pressure on the basic amenities of urban areas, which has led to increased competition for acquiring urban basic amenities. In this competition, the rich and affluent people succeed in getting these basic amenities, but the poor people fail to get these amenities. The poor people settle on vacant land outside cities, near road ,bus stand and along the railway line. Gradually their number increases leading to the formation of slums.

After independence in India, the urban population increased significantly. The urban population in India in 1951 was 6.26 (17.34%) crores which increased to 37.7 (31.16%) crores in 2011. Thus the percentage of the urban population increased almost double between 1951-2011**(Census, 2011).** In present times, people of India are migrating from the village to cities and metros in the search of better facilities. In the cities, they start to doing any kind of work for the sustenance of life, but the income from these works does not fulfill their normal needs, so they are forced to live in slums. According to the 2011 census in India 5.41% of the total population lives in the slums and 17.37% of the total urban population lives in slums. The major reasons for the development of the slums in the country are rapid population growth rate, rural urban migration, increasing unemployment increasing poverty, increased competition in urban basic amenities, expensive urban life and rapid urbanization.

Study Area

Kullu district is one of the 12 districts of Himachal

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Hydro-morphological investigations of Neeru watershed using DEM and geospatial techniques

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Abstract
Morphometric analysis is very popular among the hydro-geomorphological investigation of the river basins that deals with the linear, areal, shape and landscape aspects of river catchment. The Neeru river watershed, a left-bank tributary of Chenab River has been selected for the present study. Carto-DEM, Sentinel-2B multispectral satellite image and Topographical maps taken into account for extracting and computing watershed's various parameters adopting the geospatial techniques. This northern aligned watershed has a length, width, and perimeter of 65 km, 22.4 km, and 106.03 km, respectively, and covers 415.19 sq. km area. It is a 5th stream order watershed, with lower-order streams predominating. The drainage density of 0.81 km/km^2 indicates that it is highly permeable and thus has increased subterranean water storage capacity. The bifurcation ratio varies from 2 to 4.74, with a mean of 3.67, demonstrating strong structural control over drainage development. The study area's elongation ratio (0.67) indicates that it has an elongated shape with high relief, steep slope, high sediment load discharge, and susceptible soil erosion. The assessment indicates the role of geospatial techniques in quick appraisal of ecological indicators they will be helpful for decision makers in managing natural resource, planning, and watershed management.

Keywords: Himalayan watershed, Neeru river, Chenab river, morphometric parameters, digital elevation model

1. Introduction
Water is valuable resource and vital for all biological lives, as it gives us life and vocation (Loucks, 2000) [11]. The demand for water has risen dramatically due to population growth, water irrigation systems, and industrialization. Watershed management is necessary to achieve sustainability, and the study of watershed morphometry is an essential aspect of (Javed *et al*., 2009; Yadav *et al*., 2018; Kumar *et al*., 2021) [8, 15, 10]. Morphometric analysis is required for any hydrological investigation, including assessing and managing groundwater potential, sub-watershed prioritization, Pedology, and environmental impact (Sreedevi *et al*., 2009; Choudhari *et al*., 2018; Kumar *et al*., 2021; Kumar *et al*., 2022) [14, 7, 10]. Horton first developed it (1932) and the idea was later developed by Strahler (1952) and Coates (1956).
Morphometric analysis is the measurement and mathematical computation of the Earth's surface morphology and shape and size of its landforms (Clarke, 1966). It is the quantitative analysis of the area's shape, altitude, density, slope, profile, and drainage basin features (Savinder Singh, 1972). Drainage basin analysis is one of the most important components of any hydrological investigation. It provides essential information on the quantitative assessment of the drainage system, which is an integral aspect of basin characterization (Strahler, 1957). The analysis may assess by measuring the particular watershed's linear, aerial, and relief aspects (Nag & Chakraborty, 2003) [12]. The watershed is a natural hydrological unit delineated by topographic highs that regulate the progression and occurrence of surface water. Rivers, which are pretty significant landforms, are susceptible to tectonic movements and work efficiently as the primary component of fluvial landforms, permitting us to grasp quaternary tectonic activity in a particular area (Strahler, 1952).
In geomorphological studies, geospatial morphometric analysis is an effective technique (Kumar & Negi, 2016) [9]. Currently, remote sensing and GIS techniques have emerged as influential assets for watershed management. Previously, Srivastava and Mitra (1995), Srivastava (1997), and Agarwal (1998) [2] initiated morphometric analysis utilizing remote sensing techniques, and they believe that remote sensing techniques provide vital tools for

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A BLOCK-WISE STUDY OF POPULATION DISTRIBUTION, GROWTH, DENSITY AND SEX RATIO IN TEHRI GARHWAL DISTRICT, 1991-2011

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Abstract: The population of any region is a significant factor in determining the level of socio-economic development and environmental deterioration. It has long been considered as one of the essential topics for social scientists, especially geographers. The word "population" conjures up a slew of imagery, challenges, and potential solutions. The current study examines the changing trends of population distribution, growth, density, and sex ratio at the block level in Uttarakhand's Tehri Garhwal district. To complete the study, data were obtained from different secondary sources, such as the Tehri Garhwal Directory, census handbooks, and the census of India from three decades (1991, 2001 & 2011). The percentage method and choropleth technique have been used to present the population distribution. To identify the population growth, the decadal (1991-2001 and 2001-2011) growth has been calculated in Excel 2016. It reveals that the district is witnessing both decreased and negative population growth, mainly in the backward and rural areas.

Introduction:

Humans are unique biological creatures; their evolution is an extraordinary phenomenon of nature. It is also true that humans are cultural agents and creatures of all the cultures and cultural regions of the earth. "Population" is the state's fundamental element, and Francis Bacon first used the term in the year 1612 (Tiwari, 2004; Tripathi, 1999). Generally, the population is defined as "a group of individuals of a similar species within a community" (Mayhew, 2009) and specifically, "a group of individuals of a particular species that share the same environment and can interbreed." In simple words, "population" refers to the number of people living within a political and geographical boundary. Population studies, primarily concerned with the various branches of social and natural sciences, have a long history in terms of numbers, evolution, spread, demographic characteristics, and their distribution, density, and changes. Population distribution refers to the spatial form of a population or its distribution in a given geographical space at a given time (Clerke, 1980). The leading indicators of population distribution are population size, density, and growth used to assess regional differences. Climate, resources, and the environment are closely related to the spatial distribution pattern's typical scale characteristics (Li & Cai, 2005)

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RESEARCH PAPER

Soil erodibility mapping using watershed prioritization and morphometric parameters in conjunction with WSA, SPR and AHP-TOPSIS models in Mandakini basin, India

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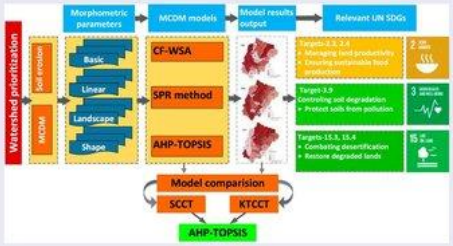
ABSTRACT

The Himalayan region is the most sensitive due to its fragility, especially in soil erosion; therefore, it is a growing concern for environmentalists and natural resource planners. The study river basin Mandakini is situated in the central part of the Garhwal Himalayan region (Uttarakhand, India), which is highly prone to soil erosion due to various hydro-geomorphological factors. The factors include precipitous slope, geology, rugged terrain, land use and drainage pattern. Therefore, to identify the erosion-prone areas of the study basin, employed watershed prioritization technique using geographical information system and remote sensing integrated with weighted sum analysis (WSA), sediment production rate (SPR) and Technique of Order Preference Similarity to the Ideal Solution with Analytical Hierarchical Process (AHP-TOPSIS) models. It is calculated by taking different parameters indicating linear, landscape, and shape parameters. All the sub-watersheds (SW) of the basin were prioritized in different categories for all models with model performance for the Mandakini river basin in the central Himalaya. The results are showing almost similar results except for high erosion-prone regions. The results of the SPR model indicate that vary large areas (43.47%) of the basin suffering from severe erosion limited in the north-central (WS11, WS12, WS21), eastern (WS2), and southern (WS22 and WS23) parts of the basin among 23 sub-watersheds. The result of model evaluation indicates AHP-TOPSIS is the efficient model in assessing soil erodibility. The study can help to undertake the precise decisions to propose an effective framework for soil erosion control measures and encourage soil conservation priorities of the region. The findings have implications for defining sustainable land resource management and conservation, which are critical to attaining the United Nations' 2030 Agenda for Sustainable Development's societal goals.



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AHP-TOPSIS; erodibility mapping; Central Himalaya; multicriteria decision making models; watershed prioritization; land degradation

1. Introduction

Soil erosion is an important agricultural and ecological issue globally and has significant economic, social and political consequences. Soil erosion is a genuine and extensive environmental issue that has influenced the lives and resources of a large number of individuals (Keesstra et al., 2016; Pramanik et al., 2021a). The method of soil erosion involves detaching, transporting and deposition of dislodged soil particles and rock fragments and then placing them by water at new places (Masselink et al., 2017). This would have long-term effects as the fertile topsoil is exhausted, and the soil's productive capacity decreases, thus worsening global food security risks (Mosbahi et al., 2013; Udmale et al., 2020). In 2012, the global potential soil erosion model estimated the current global erosion rate to be 35.9 Pg yr1 (Borrelli et al., 2017). In addition, there has been a gradual increase (0.45%), and around 0.20 million sq km of land has been affected by soil erosion in India (Borrelli et al., 2017).

Conserve, preserve and encourage sustainable land ecosystems, maintain forests sustainably and counter desertification, prevent and reverse land depletion and combat biodiversity loss due to high yield of erosive rates (Bezak et al., 2021; Chaudhary et al., 2021; Keesstra et al., 2016; Pramanik et al., 2021b). These soil conservation principles are essential in maintaining the neutrality of soil erosion at all

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An Assessment of Solar Power Potential and Prospects in India

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Abstract: Among all the developed and developing countries, India is actively contributing to providing clean, affordable and sustainable energy to the citizens and making pace to achieve the UN Sustainable Development Goals 7 till 2030. In this regard, tremendous growth in solar energy generation has been observed in the Indian energy sector. The National Solar Mission targets to attain the goal of 100 GW upto 2022. The country's solar power potential is 748.99 Gwp. The total on-grid installed capacity is 47112.55 MW, with ground-mounted (i.e., solar power plants) accounting for 41001.49 MW and solar roofs accounting for the remaining 6111.06 MW. Solar power contributes a substantial share (41.68%) in the total annual (June 2020 to May 2021) electricity generation (147678.3 MU) from renewable sources. The rise in the overall solar installed capacity (25 MW to 48556.65 MW) in the last decade represents a massive growth in solar power in the country. India is located in the tropical and sub-tropical region, receives high intensity of solar radiation (200MW/km^2) and hence possesses more potential for energy to be harnessed. The present study provides insights into the country's existing solar energy potential, installed capacity and solar power generation to achieve goals in this sector. The potential states are categorized based on installed capacity (commissioned) through the atlas and statistical computation. Solar energy policies/schemes initiated by the Government of India are reviewed concerning the progress in the energy sector.

Keywords: Solar energy potential; Solar installed Capacity; Solar atlas; National Solar Mission.

1.1. Introduction

The biosphere is endowed with diverse ecosystems[1] providing innumerable goods and services to humankind (Glavič & Lukman, 2007), so-called natural resources. Renewable resources vary in location, quantity, quality, and sustainability and are considered inexhaustible (Lele, 2019). The clean energy resources (that emits concentration of hazardous gases) and long-lasting (sustainability) like solar energy, wind energy, geothermal energy, biomass energy, etc., are regarded as an alternative source of energy (Rathore &. Panwar, 2007). Solar energy is the viable renewable energy source derived from the Sun that has been recently promised to trim down global warming (Ramachandra et al., 2011; Hosseini, 2014). The consistent nuclear fusion reactions produce solar energy, which manifests the earth's surface in the form of heat and radiation (Shaikh et al., 2017). Humans have been utilizing solar energy to meet their energy requirements since time memorial. But, the cradle of civilizations has resulted in the development of techniques and devices to harness solar energy to use it as electricity (National Geographic Society).

Energy is often considered as the driving force for the economic development of any country (Badhotiya et al., 2021). Hence, the economy of a country depends on its energy basket (Rühl et al., 2012). The energy consumption of India is one-third per capita compared to a global level (IEA, 2021). In the India's energy Thermal Power Projects (TPP) significantly contribute the large share (61.7%) as a non-renewable energy resource. Currently, coal based energy contributes about 72 % of India's electricity generation and the country's coal supplies are predicted to be exhausted by 2050 (Badhotiya et al., 2021). The use of coal will increase the total carbon emissions of the country in nearby future. TPP and coal are exhaustible and liability on these for a longer duration is questionable. Government of India (GoI) is focusing on the hydropower potential, especially in the Indian Himalayan region (IEA, 2016), irrespective of its fragility. Hydropower being renewable has environmental consequences, which seems to be ignored for economic benefits. Thus, there is need of an alternate energy source which can promise to combat the growing population demands for electricity. Such eco-friendly energy resources will definitely gain much importance and sustainability of clean environment.

India's solar energy potential is rich and vast (> 300 sunny days and 2300–3200 sunshine hours per year) because of its geographical location in the equatorial sunbelt region. As a result, the country's average intensity of daily and annual solar radiation (GHI) is 1.1–5.9 kWh/m^2 (Fig. 1a) and 414.6–2159 kWh/m^2 (Fig. 1b), respectively. The daily and annual averages of India's photovoltaic electricity production (PVOUT) are 1.37–6.03 kWh/kWp (Fig. 2a) and 500.8–2205 kWh/kWp (Fig. 2b), respectively, which are comparable to the solar radiation received in tropical and subtropical countries (Global Solar GIS). Solar energy in India varies geographically and is broadly classified into eight categories (Fig. 1). Gujarat, western and southern Rajasthan, eastern MP,

[1] An ecosystem is a geographical area where plants, animals, and other organisms as well as atmosphere and landscapes work together to form life.

जनसंख्या के भौगोलिक वितरण में समरेखा जनसंख्या विभव मानचित्रण पद्धति का अनुप्रयोग

नरेन्द्र कुमार

भूगोल विभाग, हेमवती नंदन बहुगुणा विश्वविद्यालय (केन्द्रीय विश्वविद्यालय), श्रीनगर गढवाल, उत्तराखण्ड

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सारंश (Abstract)

प्रस्तुत प्रपत्र में जनसंख्या के विश्लेषण, मापन में गुरुत्वाकर्षण मॉडल आधारित विभव प्रविधि के अनुप्रयोग को स्थानिक परिदृश्य के संदर्भ में किया गया है। इसके साथ ही जनसंख्या घनत्व एवं जनसंख्या विभव के अर्न्तसंम्बन्ध का विश्लेषण प्रकीर्ण आरेख से किया गया है। जहाँ 1991 में निम्न जनसंख्या विभव के अन्तर्गत 12.5 प्रतिशत क्षेत्रफल में व्याप्त थी, वही 2001 में इस श्रेणी के अन्तर्गत 34.38 प्रतिशत क्षेत्रफल में विस्तृत थी। जनसंख्या विभव रेखाओं के वितरण में अधिकांश परिवर्तन निम्न से उच्च श्रेणी के वर्गो के अन्तर्गत ही दृष्टिगत होता है। जनगणना वर्ष 1991, 2001 एवं 2001 में जनसंख्या विभव एवं जनसंख्या घनत्व के चरों के मध्य समस्त जनगणना वर्षो में मध्य धनात्मक, लेकिन बहुत कम मात्रा में सहसंबंध पाया गया। जिसका मान क्रमशः 0.239, 0.229 एवं 0.415 रहा है। जनसंख्या घनत्व एवं जनसंख्या विभव के मध्य सहसंबंधों के विश्लेषण से ज्ञात होता है, कि जनपद में वर्ष 1991 एवं वर्ष 2001 की तुलना में वर्ष 2011 में सहसंबंध की मात्रा में वृद्धि हुई है, जो जनपद में बढ़ती जनसंख्या सघनता को दर्शाता है।

शब्दकोशः जनसंख्या विभव, सह-सम्बन्ध, घनत्व, जनसंख्या जमाव

परिचय (Introduction)

जनसंख्या वितरण प्रारूप न सिर्फ मनुष्य के किसी क्षेत्र विशेष में बसाव सम्बन्धी अभिरूचि एवं विरूचि का द्योतक होता है, अपितु क्षेत्र में कार्यरत भौगोलिक कारकों के संश्लेषण का स्पष्ट प्रदर्शक होता है। इस प्रकार घनत्व एवं वितरण के मापन में विधियों का मूल्यांकन कर जनसंख्या वितरण तथा घनत्व में प्रादेशिक विभिन्नताओं को प्रभावकारी कारकों के सन्दर्भ में विश्लेषित किया गया है।

मापन विधियां- सामान्यतः जनसंख्या वितरण तथा घनत्व सम्बन्धी अध्ययन एक-दूसरे से अलग नहीं समझे जाते है।

प्रथम, जनसंख्या वितरण से मनुष्य के धरातल पर स्थितिजन्य प्रारूप का बोध होता है। इस प्रकार, वितरण में जनसंख्या के यथार्थ स्थल-स्थिति प्रारूप पर ही ध्यान दिया जाता है। जनसंख्या के विस्तार या फैलाव के आधार पर रेखीय या प्रकीर्ण या जमघट जनसंख्या वितरण प्रतिरूप उत्पन्न हो सकता है।

द्वितीय, जनसंख्या घनत्व का तात्पर्य जनसंख्या एवं धरातल के एक अनुपात से है। यह जनसंख्या जमाव की मात्रा का मापन है, जिसे प्रति इकाई क्षेत्र व्यक्तियों की संख्या के रूप में व्यक्त किया जाता है।

Kalyan Bharati

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साक्षरता दर में लैंगिक असमानता एवं लिंगानुपात के अर्न्तसंबन्धों का क्षेत्रीय विश्लेशणः जनपद कानपुर नगर के विशेश सन्दर्भ में

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सारांश (Abstract)

प्रस्तुत प्रपत्र में ग्रामीण–नगरीय भूदृश्य में साक्षरता दर में व्याप्त लैंगिक असमानता के प्रतिरूपों एवं लिंगानुपात के मध्य प्रतिस्थिापित सह–सम्बन्धों की विवेचना की गयी है। साक्षरता दर में लैंगिक असमानता के विश्लेषण के लिए शोफियर, (1974); कुन्दू एवं राव (1983) द्वारा प्रस्तुत असमानता सूचकांक का उपयोग किया गया है, जबकि साक्षरता दर में लैंगिक असमानता व लिंगानुपात के मध्य अर्न्तसंम्बन्धों को ज्ञात करने के लिए कार्ल पियर्सन सह–सम्बन्ध विधि (1920) का उपयोग किया गया है। कानपुर नगर के ग्रामीण परिवेश में साक्षरता दर में लैंगिक असमानता का औसतन स्तर 0.15 प्रतिशत रहा, जबकि नगरीय परिवेश की साक्षरता दर में लैंगिक असमानता का औसत मान मात्र 0.04 प्रतिशत ही रहा । ग्रामीण क्षेत्रों के 40.0 प्रतिशत सामुदायिक विकास खण्डों में साक्षरता दर में लैंगिक असमानता का स्तर उच्चतम दृष्टिगत होता है। अनुसूचित जातियों की साक्षरता दर में लैंगिक असमानता का स्तर नगरीय क्षेत्रों में ग्रामीण क्षेत्रों की तुलना में 0.04 प्रतिशत की कमी दृष्टिगत होती है। कानपुर नगर की कुल साक्षरता दर एवं अनुसूचित जातियों की साक्षरता दर के बीच में मध्यम कोटि का विभेद दृष्टिगत होता है, इस विभेद का स्तर ग्रामीण क्षेत्रों में 8.60 प्रतिशत एवं नगरीय क्षेत्रों में 9.31 प्रतिशत का अन्तर अनुसूचित जातियों एवं कुल साक्षरता के मध्य प्राप्त होता है (जनगणना, 2011)।

साक्षरता दर में लैंगिक असमानता एवं लिंगानुपात के मध्य ग्रामीण एवं नगरीय दोनों ही भूदृश्यों में ऋणात्मक सह–सम्बन्ध दृष्टिगत होता है। साक्षरता दर में लैंगिक असमानता के स्तर को कम करने के लिए शिक्षण संस्थानों के घनत्व में वृद्धि एवं समाज के निचले तबके की महिलाओं में साक्षरता के प्रति जागरूकता बढाने की आवश्यकता है। इसके साथ ही साक्षरता के महत्व, उपयोगिता का प्रचार–प्रसार अनुसूचित जातियों के लोगों में भी करने की आवश्यकता है।

शब्दकोशः साक्षरता, सह–सम्बन्ध, ग्रामीण परिवेश, औद्योगिक विकास

परिचय (Introduction)

ScienceDirect

Geomorphology
Volume 284, 1 May 2017, Pages 41-52

Identification of landslide-prone zones in the geomorphically and climatically sensitive Mandakini valley, (central Himalaya), for disaster governance using the Weights of Evidence method

Poonam Chahal [a], Naresh Rana [a], Parshant Kumar Champati ray [b], Pinkey Bisht [a], Dhirendra Singh Bagri [a], Robert James Wasson [c], Yashpal Sundriyal [a]

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https://doi.org/10.1016/j.geomorph.2016.11.008
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Highlights

- The identification of landslide prone areas in climatically and geomorphically sensitive Mandakini valley is the focus.
- Unscientific anthropogenic activities in areas located nearby streams are highly landslide susceptible.
- Final Landslide Susceptible Zonation map is validated using post disaster landslides and accuracy of the model is 77%.
- If the model of our study found affective, it can be applied for other river valleys also.

Abstract

The entire Himalayan region is prone to disasters, with many people being vulnerable to hydroclimatic threats such as extreme rainfall-driven floods, glacial lake outburst floods (GLOFs), landslide lake outburst floods (LLOFs), and landslides triggered by rainfall. Landslides and floods are related, as the former cause the lakes that burst, and floods can undercut slopes and cause landslides. During the past 200years, landslides and floods caused by LLOFs in the Garhwal Himalaya have occurred in 1894, 1970, and 1978; but the most disastrous event, in terms of loss of life and economic impact, occurred in June 2013, which was a result of extreme rainfall in the Higher Himalaya and breaching of a moraine-dammed lake, very short-lived LLOFs, and rainfall-induced runoff and landslides. Outmigration from the area as a result of the 2013 event has caused anxiety about the future of the economy and also concerns about security of a state that has an

ScienceDirect

Geomorphology
Volume 284, 1 May 2017, Pages 130-141

Pattern of Holocene glaciation in the monsoon-dominated Kosa Valley, central Himalaya, Uttarakhand, India

Pinkey Bisht [a], S. Nawaz Ali [b c], Naresh Rana [a d], Sunil Singh [a], Poonam [a], Y.P. Sundriyal [a], D.S. Bagri [a], Navin Juyal [c]

https://doi.org/10.1016/j.geomorph.2016.11.023
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Highlights

- Four stages of glaciations were identified since late glacial to late Holocene.
- Glacial stages were preserved in the form of curvilinear moraine ridges.
- Glacier responded to the minor changes in the temperature and moisture.
- Evidence of Last Glacial Maximum and Little Ice Age has been observed in Kosa valley.

Abstract

Reconstruction based on the geomorphology, lateral moraine stratigraphy, and limited optical chronology indicate that the monsoon-dominated Kosa Valley experienced four glacial advances during the late glacial to late Holocene. The oldest and most extensive glaciation, which is termed as Raj Bank Stage-1 (RBS-1), is represented by the degraded moraine ridge. This glaciation remains undated; however, the chronology of outwash terrace gravel dated to 12.7±1.3 ka indicates that the RBS-1 probably represents the Last Glacial Maximum (LGM). The second glacial advance (RBS-2) is preserved as a curvilinear lateral moraine and is dated to 6.1±0.4 ka. The third glacial advance viz. RBS-3 is bracketed between 5.0±0.5 and 4.0±0.4 ka. Following this, the glacier receded in pulses that are represented by two distinct recessional moraines (RBS-3a and b). The forth glacial stage (RBS-4), which is dated between 2.2±0.2 and 1.6±0.2 ka, shows a pulsating recession and is represented by a prominent recessional moraine (RBS-4a). Whereas, presence of unconsolidated, poorly defined moraine mounds proximal to the glacier snout are ascribed as neoglacial advance corresponding to the Little Ice Age (LIA).

ScienceDirect

Geomorphology
Volume 284, 1 May 2017, Pages 17-30

Paleofloods records in Himalaya

P. Srivastava [a], A. Kumar [a], S. Chaudhary [b], N. Meena [a], Y.P. Sundriyal [c], S. Rawat [a], N. Rana [c], R.J. Perumal [a], P. Bisht [c], D. Sharma [c], R. Agnihotri [d], D.S. Bagri [c], N. Juyal [e], R.J. Wasson [f], A.D. Ziegler [g]

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https://doi.org/10.1016/j.geomorph.2016.12.011
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Highlights

- Paleoflood records in major rivers like the Indus, the Alaknanda-Mandakini and the Brahmaputra are explored.
- The chronology suggests that the Alaknanda-Mandakini Rivers experienced extreme floods during the Medieval Warm Phase.
- During the Holocene climatic Optimum, the floods in the Indus river were an order of magnitude higher than the modern.
- The Brahmaputra river valley experienced a megaflood during 8–6ka BP.

Abstract

We use paleoflood deposits to reconstruct a record of past floods for the Alaknanda-Mandakini Rivers (Garhwal Himalaya), the Indus River (Ladakh, NW Himalaya) and the Brahmaputra River (NE Himalaya). The deposits are characterized by sand-silt couplets, massive sand beds, and from debris flow sediment. The chronology of paleoflood deposits, established by Optically Stimulated Luminescence (OSL) and ^{14}C AMS dating techniques, indicates the following: (i) The Alaknanda-Mandakini Rivers experienced large floods during the wet and warm Medieval Climate Anomaly (MCA); (ii) the Indus River experienced at least 14 large floods during the Holocene climatic optimum, when flood discharges were likely an order of magnitude higher than those of modern floods; and (iii) the Brahmaputra River experienced a megaflood between 8 and 6ka. Magnetic susceptibility of flood sediments indicates that 10 out of 14 floods on the Indus River originated in the catchments draining the Ladakh Batholith, indicating the potential role of glacial lake outbursts (GLOFs) and/or landslide lake outbursts (LLOFs) in compounding flood magnitudes. Pollen recovered from debris flow deposits located in the headwaters of the Mandakini River showed the presence of warmth-loving trees and marshy taxa, thereby corroborating the finding that floods occurred

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Engineering Geological Evaluation of Kakoragad Small Hydroelectric Project, Uttarakashi District, Uttarakhand

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Abstract: *The proposed Kakoragad small hydroelectric project is a run of the river scheme, on Kakora River near Harsil in Uttarkashi district of Uttarakhand. The water will be diverted by an 18m long rectangular trench type weir at an altitude of ±2942m. The diverted water will be carried to the powerhouse through power tunnels over a distance of 1629m to produce 12.5MW of electricity. The whole project is located within the rocks of Vaikrita Group. This study includes detailed discussions on geological setting in addition to highlighting the anticipated Engineering Geological problems likely to be encountered during construction of the project. The rocks at the project site have been classified using Rock Mass Rating (RMR) system and also by Q-system in order to predict rock load and support requirements.*

Keywords: *Kakoragad small hydroelectric project, RMR, Q-system, in-situ stresses, remedial measures*

I. Introduction

The snow fed perennial rivers of Himalaya have huge hydropower potential. This non-exhaustible resource is an effective means to meet the rapidly rising energy requirements of the country. Several mega and micro scale hydroelectric projects are already functioning in the Himalayan region, while many more are under construction as well as planning stages across the Himalayan Rivers. The suitable location for Run-of-the-River Schemes (RORS), in Himalaya is a challenging task due to the fragility and high seismicity of the terrain. Since the terrain is highly sensitive environmentally, safe water conductor structures such as tunnels are more preferred as compared to open channels, which involve huge cuttings of the slope and other attendant environmental issues. These structures have minimum environmental problems, easy to construct and maintain with extremely high stability against earthquakes. The stability of underground openings is dependent on rock mass condition, in-situ stresses, support stiffness, size and shape of the cavity, method of construction and sequence of construction practice among other factors. In the present case, the Engineering Geological problems associated with the construction of a small hydropower project has been discussed. Here, the proposed rectangular trench type weir will help to ensure free flow of water without stagnating the water across the river course.

The Kakoragad small hydroelectric project is a Run-of-the river scheme (RORS) for power generation by exploiting the hydro power potential of the Kakora stream, a tributary of the Bhagirathi River. The project is situated near Harsil, about 75km from Uttarkashi towards Gangotri (Fig 1). The Kakora stream is a perennial stream, which originates from the snow clad mountains having a peak elevation of 5900m and flows in the south-west direction up to Harsil village, where it meets the Bhagirathi River. This Engineering Geological problems of this small hydroelectric project have been discussed with particular reference to five important project components namely diversion weir, water conductor system, forebay, penstock and powerhouse.

II. Geological Setting Of Project Area

The Kakoragad small hydroelectric project is situated in Higher Himalayan terrain of Garhwal Himalaya. The rocks exposed in and around the project site belongs to Vaikrita Group. The region has undergone high grade metamorphism resulting in the formation of Garnet-Quartz-Mica Granulite interbedded with Biotite-Mica Schist. The Biotite-Mica Schist shows trapped emplacements of anhedral to subhedral crystals of quartz. Thick debris cover could be seen all along the stretch of the Kakora stream from Harsil and further upstream up to the proposed weir site. However, a small patch of rock is seen at the proposed weir site. Debris materials mainly consisting of big rock blocks mixed with silty soil are present close to the valley face on the left bank near diversion site and desilting tank. At the diversion site, rocks show well developed foliations with less developed joints. Huge thickness of debris found at

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Engineering Geological Evaluation of Siyan Gad Small Hydroelectric Project, Uttarakashi District, Uttarakhand

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Abstract: *The proposed Siyan Gad small hydroelectric project is a run of the river scheme, on Siyan Gad River near Harsil in Uttarakashi district of Uttarakhand. The water will be diverted by a 6m high weir through a 2.72 km long power tunnel to a surface power house near Jhala village to produce 5 MW of electric power. The whole project is located within the rocks of Harsil Metamorphics of Vaikrita Group. This study includes detailed discussion and control measures for engineering geological problems likely to be encountered during construction or post construction period. The rocks at the project site are classified according to Rock Mass Rating (RMR) system and also by Q-system in order to predict rock load and support requirements.*
Keywords: *Siyan Gad small hydroelectric project, RMR, Q-system, in-situ stresses, remedial measures.*

I. Introduction

The Himalayan region is rich with perennial rivers, which are potential enough to meet the rapidly rising energy requirements, but construction of micro to mega hydroelectric projects are challenged by the fragility and high seismicity of the terrain. The stability of underground openings is dependent on rock mass condition, in-situ stresses, support stiffness, size and shape of cavity, method of construction and sequence of construction among other factors.

The Siyan Gad small hydroelectric project is a run-of-river scheme for generation of 5MW by exploiting hydro-power potential of Siyan Gad stream, a tributary of Bhagirathi River. The Siyan Gad stream is fed by rain, spring water and glacial ice melts. The small hydroelectric projects in general have five major components namely Diversion Weir, Water Conductor System, Forebay, Penstock and Power House. Location Map of the study area shown in Fig 1.

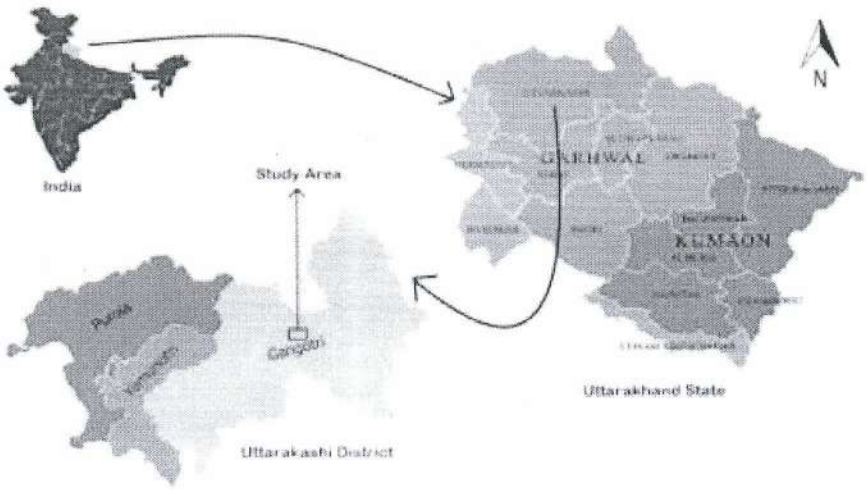

Fig.1. Location map of the study area

II. Geology of Project Site

The Siyan Gad small hydroelectric project is situated in Higher Himalayan terrain of Garhwal region. The rocks in the area belong to Vaikrita Group, named by Griesbach (1891). The medium to high-grade metamorphics of Vaikrita Group is known as Harsil Metamorphics. The lithology encountered in this area includes mainly micaceous quartzites, which consist of thick quartzite bands alternating with thin bands of mica schist. The mica bands mainly consist of biotite and muscovite minerals. Because of the presence of thick

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Kinematic analysis of slopes between Preng and Ganderbal, Jammu and Kashmir Himalaya, India

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Abstract: Slope stability is a matter of concern for many projects such as buildings, bridges, hydro projects, highways, railway, canal and tunnels in hilly terrain. The present study is carried out between Preng and Ganderbal in Ganderbal district of Jammu and Kahmir. The Ganderbal hydro project is located on the left bank of the river Sind. The Sind River is one of the tributaries of Jhelum River. Slope Mass Rating (SMR) has been done to identify different classes of slopes, their vulnerability to instability and Kinematic analysis by Markland's Method, as the said method is applied to decipher the possible mode of failure and directions in the study area. The said approach was preferred considering the heterogeneous rock mass and being anisotropic with infinitely variable strength parameters that are difficult to determine precisely.The study concludes with the assessment of rock mass conditions and further categorization into fair and poor categories. As the area is facing the recurrences of mass wasting and slope failures, it could broadly be classified into planar and wedge failure. An attempt has been made for the assessment of the rock mass leading to better alignment of highways, tunnels and to foresee any potential rock slope failure during excavation/construction.SMR study concludes that the area falls in partially stable to unstable class.

Key words: Kinematic Analysis, Markland's Test, SMR, Ganderbal, Jammu and Kashmir Himalaya.

सारांशः पहाडी क्षेत्रों में पहाडियों के ढाल की स्थिरता कई परियोजनाओं जैसे भवन, पुल, जलविद्युत परियोजना, राजमार्ग, रेल–लाइन, नहरों तथा सुरंगों के निर्माण में चिंता का विषय होता है। प्रस्तुत शोध पत्र में ढालों की स्थिरता का अध्ययन प्रेंग तथा गंदेरबल के मध्य किया गया है, जो कि जम्मू एवं कश्मीर राज्य के गंदेरबल जिले के अंतर्गत आता है। गंदेरबल जल–विद्युत परियोजना सिंद नदी के बांये तट पर स्थित है। सिंद नदी झेलम नदी की सहायक नदियों में से एक है। ढालों की स्थिरता का मूल्यांकन ढालों के विभिन्न वर्गों की पहचान के लिए, ढालों की संवेदनशीलता एवं अस्थिरता का आकलन मार्कलैण्ड विधि द्वारा प्रगतिकी विश्लेषण के माध्यम से किया गया है। क्योंकि यह विधि ढालों के सरकने या क्षरण होने की दिशा तथा संभावित प्रकार का आकलन करने के लिए उपयुक्त है। उक्त विधि को इसलिए भी वरीयता दी गयी है क्योंकि अध्ययन क्षेत्र में विजातीय शैलो की अधिकता है जिसके कारण असमदैशिक एवं असंख्य परिवर्तनशील कारकों तथा मजबूती की स्थिति को विशुद्ध रूप से ज्ञात करना कठिन है। इस अध्ययन से यह निष्कर्ष निकाला गया है कि शैलों की स्थिति का आकलन उन्हें पुनः विभाजित करके सुदृढ एवं कमजोर क्षेत्र को बार–बार बृहत क्षरण एवं ढालों के गिरने / सरकने का सामना करना पड़ता है। ऐसी स्थिति में मोटे तौर पर शैलों के टूटने को फानाकार एवं तलीय टूटन में विभाजित किया गया है। प्रस्तुत अध्ययन में शैलों के लक्षणों के आंकलन के आधार पर प्रमुख रूप से राजमार्गों तथा सुरंगों के निर्माण के लिए उपयुक्त रेखन का प्रयास किया गया है, तथा खुदाई एवं निमार्ण कार्य के समय अनुमानित एवं संभावित शैल टूटन का आकलन किया गया है। उक्त विधि से ढालों की स्थिरता के मूल्यांकन के पश्चात् यह निष्कर्ष निकलता है कि उक्त क्षेत्र आंशिक रूप से स्थिर व आंशिक रूप से अस्थिर श्रेणी में आता है।

सूचक शब्दः प्रगतिकी विश्लेषण, मार्कलैण्ड विधि, ढालों की स्थिरता का मूल्यांकन, गंदेरबल, जम्मू एवं कश्मीर हिमालय।

INTRODUCTION

The Himalaya being the youngest mountain chain of the world is tectonically and climatically sensitive (Poonam *et al.* 2017, Sundriyal *et al.* 2015). Problems of slope failure are very common in the Himalayan region. Every year the region faces several landslides, which create risk to human lives and infrastructures such as highways and civil structures like dams, buildings etc. Landslide is defined as the movement of a mass of rock, debris or earth down a slope (Cruden 1991), can be triggered by a variety of external stimuli, such as heavy rainfall, intense earthquake, water level change, and rapid stream erosion that cause a rapid increase in shear stress or decrease in shear strength of slope- forming materials (Asthana & Sah 2007; Bhambri *et al.* 2017; Chaudhary *et al.* 2010).

The state of Jammu & Kashmir is strategically very sensitive and distinct with respect to topography and climate, most part of the state is mountainous; the topography along with the climatic condition and various anthropogenic interventions have made it susceptible to natural hazards. Landslides are one of the natural hazards that are common and peculiar to the state. Almost every year the state faces the problem of landslides which affect society in many ways like loss of lives, damage to houses, agricultural land and other infrastructures like roads and dam sites. The vulnerability has increased because of presence of unstable and fragile lithology, seismicity and various unscientific developmental activities. Deforestation, unscientific construction, terracing, encroachment on steep hill slopes are a few and foremost anthropogenic activities which have increased the frequency and intensity of landslides.

The study area comes around a proposed New Ganderbal Hydro Electric Project in Ganderbal district (Fig. 1A). It is a run-off the river scheme located on the left bank of Sind river. Besides power generation, the project envisages providing drinking water facilities and irrigation to the local command

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Water quality assessment of the reservoirs of Lambagad and Srinagar in relation to suitability for uses, Alaknanda Valley, Garhwal Himalayas, Uttarakhand, India

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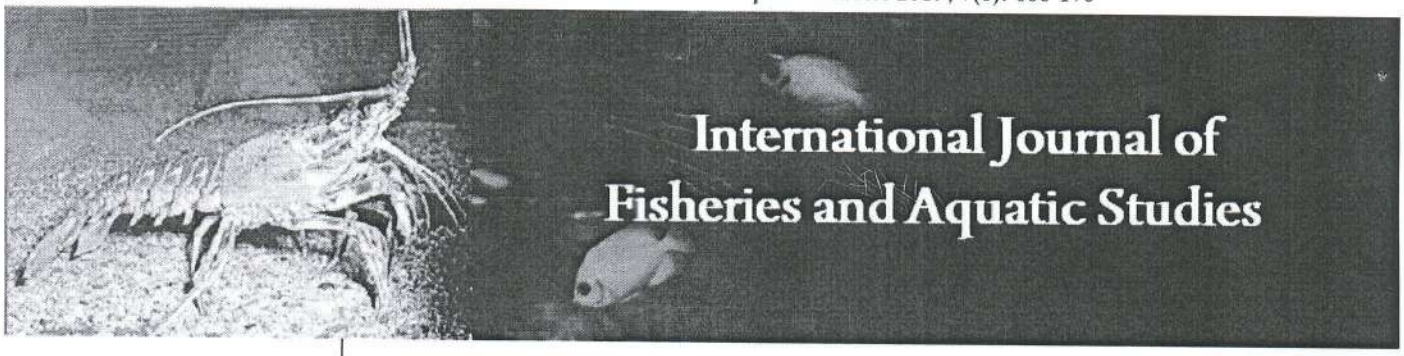
Abstract

Reservoirs are the anthropogenic features that accumulate a large volume of water behind them and in turn alter the physico-chemical and biological characteristics of water. The Alaknanda river is a major source of drinking water in the study area. Present study outlines the anomalies in the water in two reservoirs of Lambagad and Srinagar. The two reservoirs were selected and their physico-chemical and biological characteristics measured in laboratory and in field. The data obtained was merged into a single number i.e. water quality index. With this index the upstream and downstream effects on the water quality was calculated in the form of anomaly. It was observed that WQI in the downstream of reservoir has improved as compared to the upstream. WQI in the downstream of reservoir at Lambagad in pre and post monsoon was 140.462 and 87.76 respectively as compared to 258.421 and 215.1 in the upstream of the reservoir. WQI in the downstream of reservoir at Srinagar in pre and post monsoon was found to be 67.3416 and 57.8746 respectively as compared to 86.9244 and 64.66 in the upstream. Water quality Index in the Srinagar reservoir in pre and post monsoon seasons are123.193 and 96.0176 respectively. The study concludes that the downstream site of reservoirs has better water quality as compared to upstream.

Key words: Water quality index, water quality anomaly, weighted arithmetic index method.

Introduction

Rivers are one of the biggest source of potable water. With the advent of anthropogenic influences these water bodies are under severe environmental stress. The Alaknanda river originating from Satopanth glacier located in higher Himalaya passes through such anthropogenic zones and the water quality is deviated. Reservoirs are one such anthropogenic feature which convert the fluviatile form of the river into the partially lacustrine and hence are able to deviate from the physical, chemical and biological parameters associated with water of the river. This in turn causes a corresponding water



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Water quality assessment of Tehri dam reservoir in the context of its potential in aquaponics, Uttarakhand

Rawat AM, Bagri DS and Kumar S

Abstract
The State of Uttarakhand is one of the Himalayan States having more than 3/4th of its geographical area as mountainous. Agriculture is not of commercial nature in most of its parts except in the Terai ones. The geographical constraints are hampering the traditional form of agriculture here. The reservoir of Tehri dam, having area nearly 52 Km^2, offers an opportunity to switch over to the non-traditional practices in the sector like aquaponics and that too the commercially viable ones. This soil less media can be a potential site for the new and innovative farming practices. In the study area, the water quality of the reservoir is assessed by the authors and observed that the parameters like pH, dissolved oxygen, temperature and nitrates, are quite suited to the Aquaponics with a variety of plants. Sampling has been done in Dobra Chanti, Koti, and Pipaldali all coming under lake area at various parts. The pH, DO, Temperature, Nitrate at Dobra Chanti is 9.2,8.5 ppm, 24.9 degrees, 2.3 respectively. The values for Koti are 9.23, 9.1 ppm, 22.5 degrees, 3.5 ppm respectively and for Pipaldali are 9.17, 9.3 ppm, 23.3 degrees, and 0.4 ppm respectively.
As the comparative study of the above parameters was done by [1, 2, 7] it is found that the Tehri dam reservoir has a high potential for the said bio-integrated system. Thus, the given idea facilitates that the nutrient solution may lead to an increase in commercial agriculture, agro-business which will culminate in employment opportunities and further research and development in this field. Moreover, such practices may also be carried out in the reservoir and other impounded lakes in the state.

Keywords: Water quality, reservoirs, mountains, aquaponics, sustainable agriculture, business model

1. Introduction
Aquaponics is a very innovative form of agriculture which makes a kind of ecosystem between the fish and certain plants that can grow in water. This is totally a soil less form of agriculture. Here the nutrient for the plant growth is provided by the excretory products of fish which are broken down by microorganisms so that the resultant by-product can be used [7]. This method allows a sustainable growth to the crop without using the fertilizers and chemicals as the harmless nutrients acts as a Natural fertilizers and ensure the growth of plants [1, 24]. It allows us to save maximum water that could be lost in the conventional mode of farming through percolation into the land. The Himalayan terrain is very rugged and at the same time, the water and land resources for the crop production are too limited to be viable for commercial production. At such terrains we need a very different form of agriculture that could generate more output as compared to the conventional mode. Aquaponics is one such method that is capable of producing up to three to six times the quantity of plants output of a conventional planting system [22], and utilize less amount of freshwater needed to produce fish in a conventional aquaculture system [15]. So this system is perceived to be a possible sustainable solution to the inadequacies of fish and crop production as well as unemployment and trade deficit (due to high importation of food products) in many underdeveloped and developing countries [7]. From an environmental perspective, aquaponics stands out as a resource efficient system of food production that minimizes the externalities and allows cascading of nutrients that otherwise would cause eutrophication problem in the surrounding [2, 16, 17].
We intend to develop a new model of aquaponics in mountain agriculture by utilizing the huge area of Tehri dam reservoir as an aquaponics media. Tehri dam has been a source of employment for the locals in the last couple of years. The fish production in the reservoir is at a very large scale. The idea of changing the aquaculture into aquaponics is the basic theme of the present study.

COMPARATIVE EVALUATION OF DIGITAL ELEVATION MODEL BASED ON ELEVATION DATA AND TERRAIN ATTRIBUTES LEADING TO THEIR VALIDATION

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KEYWORDS: Elevation data, Accuracy, Error statistics, Terrain attributes.

ABSTRACT: Digital Elevation Model (DEM) is the 3D-representation of terrain surface in the discrete form and a standard tool to examine the hydrological and research application related to terrain characterization, landscape and water resources management. It helps in identifying physical features of an area, watershed delineation and stream network generation. However, several issues related to DEM's accuracy is the utmost concern for researchers. The present study is based on the comparative studies of DEMs viz., Cartosat-1, SRTM, ALOS and ASTER having the same spatial resolution of 30m each, under two different categories of elevation data and topographic attributes. The vertical accuracy of DEMs is examined by using ground control points as a reference level of elevation generated from topographic map. Analysing different sources of error in the DEMs, the RMSE and MAE based validation of elevation suggests that Cartosat-1 shows relatively high vertical accuracy (RMSE=45.2 & MAE=7.7) and ASTER shows the least (RMSE=60.5 & MAE=34.6). The grid size, spatial variation and vertical accuracy of DEM are among the prime attribute of data sources to determine the variation in basin morphometry. The study area shows a gradually undulating topography with 5th order drainage network. An inference can be made out of research study that the mean elevation values of ALOS, SRTM, Cartosat-1 are relatively lower than ASTER whereas differences in stream parameters are also observed. Mean bifurcation ratio value, which varies from 3.8-4.4, indicates that the area is structurally controlled.

1. Introduction:

Digital Elevation Model (DEM) is having the infinite sets of application in the areas of geomorphology, characterisation of watershed, ecology, surface runoff, modelling related to hydrology, soil erosion potential & agriculture etc. Significance of accurate DEM is mandatory

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Trend Analysis of Annual and Seasonal Time Series over the Last 46 Years in Asan Watershed, Doon Valley Based on Gridded Data Set

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ABSTRACT

The study is carried out with changing long-term trend and variation in one of the significant climatic element. The daily gridded rainfall data of spatial resolution 0.25°x 0.25°, for the last 46 years *i.e.* 1970-2015, has been processed for the Asan watershed located in Doon Valley, Uttarakhand. The non-parametric Mann-Kendall (MK) test together with Sen's Slope Estimator has been used for the determination of trend and slope magnitude in the watershed respectively. The gridded statistics of annual and seasonal precipitation trends have been studied here to achieve the objective. It has been observed that the magnitude of precipitation in annual and monsoonal time series are increased for all grids except for grid 6 and 8 which show a decreasing trend. The Post Monsoon time series shows a decreasing trend in all grids except for grid 6 which show positive whereas both the summer and winter rainfall show increasing trend except for grid 6. The Coefficient of variability shows variation for annual and seasonal rainfall suggesting overall insignificant changes in the area.

Keywords: Statistical trend analysis, Mann-Kendall test, Sen's slope estimator, Rainfall variability, Watershed

INTRODUCTION

Food production, conservation and management of water resources are a prime and significant concern of any development and planning. Change in climatic conditions with time is responsible for the loss of freshwater availability. IPCC (2007), revealed that in the mid of 21st century, 10-30% of the water present in the earth will project up and also fall in annual average rainfall. Precipitation is important for the nourishment of vegetation and agriculture. Particularly in developing countries, the adverse effect of change in climate on small farmers is emphasized, as they are mostly dependent on natural and traditional methods of cultivating crops (UNDP, 2014). Also, it plays an important role in shaping hydrology and water quality. Rainfall together with temperature affects the variability of weather to a large extent to determine the crop cultivation in a different region of the world.

Climate change with reference to rainfall variability also discussed by various researchers *viz.*, Asfaw *et al.* (2018), Pandey *et al.* (2001), Gajbhiye *et al.* (2015; 2016), Longobardi *et al.* (2009), Hamilton *et al.* (2001), Birsan *et al.* (2005), Jhajharia *et al.* (2009, 2012, 2014 a, b), Kumar *et al.* (2010), Krishan *et al.* (2016; 2018), Xu *et al.* (2007), Modarres *et al.* (2007).

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Sedimentary thickness of the northern Indo-Gangetic plain inferred from magnetotelluric studies

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Knowledge of the sedimentary thickness and configuration of the basement structure are important to estimate the seismic hazards in active foreland basin. We present sedimentary thickness of the northern Indo-Gangetic plain estimated from impedance tensors of 12 magnetotelluric sites. Occam's one dimensional inversion scheme was applied to invariant of the magnetotelluric tensors for the period range of 0.001–1 sec at each site. Inverted one dimensional model corroborates north-easterly dipping Indian basement and accordingly increased thickness of the sedimentary column towards north and east direction. The top sedimentary layers of varying thickness and resistivity are correlated with the known borewell logs and previous geophysical studies around the study area. Significant difference is observed in the resistivity of the Indian basement and thickness of the sedimentary column across the Delhi Hardwar Ridge. The difference in resistivity may be an indicative of variation in compactness and degree of saturation of the sedimentary cover and the nature of the Indian basement rock across the Delhi Haridwar Ridge.

Keywords. Indo-Gangetic plain; Himalaya; resistivity; magnetotelluric; 1D inversion; dimensionality.

1. Introduction

The sediments of the Indo-Gangetic plain (IGP) have varying thickness of ~1–6 km (Lyon-Caen and Molnar 1985; Borah *et al.* 2015). These sediments have been deposited over a deep trough formed by solid rocks of the Indian crust (Sastri *et al.* 1971; Rao 1973; Singh 1996). Geology and tectonic setting of the IGP, is closely related to the formation of the Himalayan orogeny. Neo-tectonically active IGP was formed in response of the Himalayan uplift after the collision of India and Eurasia continental plates (Dewey and Bird 1970; Pati *et al.* 2015). Due to the collision and subsequent thrusting, the old sedimentary prism of an intermediate sea was folded, faulted, thrusted and uplifted along with its basement in Cenozoic period (Burbank *et al.* 1996; Najman *et al.* 2004). From north to south, these fault lines are named as Indo-Tsangpo suture zone (ITSZ), South Tibetan Detachment (STD), Main Central Thrust (MCT), Main Boundary Thrust (MBT), Himalayan Frontal Thrust (HFT) (Gansser 1964; Ni and Barazangi 1984; Yin 2006; Jain *et al.* 2016; Thakur *et al.* 2018). Further south of the HFT, a flexure was developed on the Indian plate due to collision and partial subduction below the overriding Eurasian plate. Later, the debris of the Himalayan sediments brought by the major perennial rivers namely, Indus, Ganga, and Brahmaputra along with their

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RESERVOIR EFFECTS IN THE DISSOLVED OXYGEN OF ALAKNANDA RIVER, GARHWAL, HIMALAYA, UTTARAKHAND, INDIA

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ABSTRACT

Dissolved Oxygen is one of the most crucial component that determines the holiness of any water body. Rivers has been the lifeline for many civilizations they pass by, and the present scenario too shows the huge dependency of humans in the rivers for one or many reasons. These dependencies in the rivers has huge impact in the quality of rivers and their health. Creation of manmade reservoirs for the power generation in the Himalayan Rivers, has been a common trend. The reservoirs convert the riverine form of the water to the lacustrine one. In the present study the impact of man-made reservoir in the dissolved oxygen of the river has been worked out in pre and post monsoon seasons. The dissolved oxygen within the reservoirs has depleted compared to the upstream and the downstream of reservoir in both the seasons. The DO within the reservoir in pre-post monsoon seasons is 5.1 & 4.55 respectively, which is low compared to the upstream values of 5.53 and 5.85 respectively in the said seasons. The downstream DO values also shows the better conditions of 6.5 and 7.15 respectively. Thus, the study suggests that the Srinagar reservoir has the capability to deviate the nature of the flowing water.

Keywords:

Dissolved oxygen; Himalayan River; Water Quality; Reservoirs.

1. Introduction

Dams are physical barriers in river systems, and they and their associated impoundment water can result in changes to the natural flow regime, which in turn may change the physico-chemical parameters associated with the water Palmer et al. (1990). Ward & Stanford (1983) suggests that the dams and their reservoirs has the ability to shift the parameters longitudinally upstream or downstream. Similar to wetlands and larger reservoirs, small reservoirs temporarily store storm-water that is gradually released, thus delaying and mitigating peak flows (Larm, 2000; Guo, 2001; Ravazzani et al., 2014).Dissolved oxygen being a very sensitive aspect of a river can vary within the reservoir depending on whether reservoir releases occur from the surface or near the bottom of the water column (Willey et al., 1996; Neumann et al., 2006). This study focuses on the effects of a small reservoir in the dissolved oxygen of pristine river of Himalaya viz. Alaknanda and how the conversion of the free flowing river water to a different continuum i.e, reservoir makes the river to behave in a very different manner that is manifested in its parameters.

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REVIEW PAPER

Analysis of tectonic deformation on channel morphology through quantitative geomorphic indices and DEM derived drainage system

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Abstract
Drainage basin dynamics of any river is controlled by geomorphic attributes which include both surface and subsurface characteristics of a watershed. These characteristics comprise erosional and deformational processes affecting the hydrological and morphological conditions of the watershed. Similarly, the tectonic setup of the watershed influences the terrain topography and geomorphology as well. The paper deals with the evaluation of DEM-derived parameters related to morphometry and tectonic setup in the Asan watershed, Doon Valley, Uttarakhand. The assessment of active tectonics in the study area is based on the parameters related to the morphometry and morphotectonic characters of the watershed. These terrain attributes are determined using Cartosat-1 DEM (10 m) using GIS to investigate the structural setting. The parametric evaluation concerning morphometric analysis helps to understand their significance in watershed prioritization and management while the tectonic analysis helps to determine the structural setup and identifying the hazard-prone area, if persists, in the watershed. The study area falls downhill of tectonically active Lesser Himalaya and Siwaliks, make it an ideal location to determine the degree of relative tectonic activity in the area. The average of measured attributes is used to evaluate the combined classification of the Relative Active Tectonic Index (R_i). The outcome reveals that the watershed is tectonically active that experienced a differential rate of tectonism and have a consistence relationship between structural disturbances and basin geometry.

Keywords Morphometry · Geomorphic indices · Watershed · DEM · GIS · Relative active tectonic index

Introduction

The active Himalayan mountain chain is subjected to various deformational processes because of tectonic uplift, weathering and denudational processes (Valdiya 2003; Perez-Pena et al. 2010). The geomorphological setup of a particular watershed is strongly affected by the deformational processes occurring within them. It is strongly dependent upon the tectonic activities occurring into it, which influences the drainage system, terrain topography and landscape development. Tectonic geomorphology describes the formation of geomorphic features which is the results of the relationship between the tectonic and surficial processes (Burbank and Anderson 2001). In controlling river behaviour and the development of drainage network, tectonism plays a significant part (Holbrook and Schumm 1999; Sinha-Roy 2001; Valdiya and Narayana 2007). This can be described both qualitatively and quantitatively (Hare and Gardner 1985; Keller and Pinter 2002). The drainage network in active regions is susceptible to tectonic features viz., faults, folding and tilting. River and streams are the significant landforms that are very sensitive to tectonic movement as these affected by incision, diversion and asymmetry in a tectonic environment (Cox 1994). Watersheds behave as the fundamental unit of the fluvial landforms and act as an ideal entity to understand the tectonic activity in the area (Strahler 1964). Geomorphological quantitative studies of the basin relate with the study of morphometric and morphotectonic attributes of tectonic geomorphology. The geomorphic feature gives quantitative information about the tectonic processes

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Hydrological Characteristics of 7th February 2021 Rishi Ganga Flood: Implication towards Understanding Flood Hazards in Higher Himalaya

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ABSTRACT

A flash flood that originated from Raunthi Gad-a tributary of the Rishi Ganga river, in Garhwal Himalaya, caused unprecedented loss to lives and damaged two hydropower projects on 7th Februray 2021. In order to asses the flood magnitude, the flow parameters of the flood were calculated using the super-elevation of the flood marks preserved in the flood affected valleys.

The textural characteristics of the flood deposits in the upper reaches of the valleys indicate dominance of debris flows. The peak discharge upstream of the confluence of Rishi Ganga and Dhauli Ganga was around $1.1x10^5$ m^3/s, which was four order of magnitiude higher than the normal peak discharge (~ 3 m^3/s). The flow achieved a velocity of 30±3 m/s. An exponential reduction in the flow velocity (from ~37 to 2 m/s) with distance is observed. For which the river gradient and increase in sediment load is implied flow that along its entrained way downstream between Raini and Tapovan. Considering the sensitivity of paraglacial zones to climate change, the paper calls for detailed studies pertaining to the response of paraglacial zones to extreme weather events. Importnatly, it is necessary to have more hydrological data covering multiple valleys for predictive model simulation of the nature and magnitude of such disasters in future.

INTRODUCTION

India stands among the six most flood-affected countries in the world (Luo et al., 2015). Floods in Himalaya are generally produced by extreme precipitation events (e.g. Sah et al., 2003; 2010; Juyal, 2010; Rana et al., 2012), landslide lake outburst floods (LLOFs) (Wasson et al., 2013; Rana et al., 2013), and the glacier lake outburst floods (GLOFs) (Korup et al., 2006) or due to the meteorological disturbances (Srivastava et al., 2017; Kale, 2004; Ziegler et al., 2014) or the combination of the above factors. The June 2013 Kedarnath flash-flood was triggered by a combination of high rainfall, snowmelt and subsequent Chorabari lake outburst (Sati and Gahalaut, 2013; Rana et al., 2013; Doval et al., 2013). It has been observed that debris flow triggered by high intensity rainfall events from paraglacier zones are one of the major factors responsible for devastating the infrastructures in the Higher Himalaya (Sundriyal et al., 2015).

The upper Alaknanda river catchment is dominated by the glacial and paraglacial processes in which the Rishi Ganga, a tributary of Dhauli Ganga, contains the largest concentrations of glaciers. (Fig. 1). On 7th February 2021, at around 10:30 a.m. a debris laden flash flood originated from Raunthi Gad -a tributary of Rishi Ganga. The flood water devastated a 13.2 MW hydropower project at Raini village taking at least 80 lives. Further downstream, in the Dhauli Ganga valley, it destroyed an under-construction barrage of 520 MW hydropower project and killed nearly 150 people (either swept away or buried/trapped in the tunnel).

From future risk assessment point of view, this flood raised two important questions: (i) what was the process responsible for the genesis of the debris-laden flash flood from a small stream? (ii) What determined the pattern of damage in the valley? To address these questions, hydrological parameters are employed for determining the magnitude and characteristic of this flood as it moved down valley. The geomorphic imprints left behind by the flood are documented by using the total station to reconstruct pre- and post-flood scenarios with respet to channel geometry. Further, the hydrological characterization of the flood was done using empirical methods (for calculating flood velocity and discharge).

STUDY AREA

The Rishi Ganga catchment (area ~690 km^2) is located in the Garhwal region of Central Himalaya, India (Fig.1). The Rishi Ganga river, a sub-tributary of the Alaknanda river, emanates from the group of glaciers in the Nanda Devi Biosphere Reserve (NDBR) and joins Dhauli Ganga river near Raini village. The elevation in the catchment ranges from ~1930 m above mean sea level (a.m.s.l.) at the confluence to 7817 m a.m.s.l (Nanda Devi). The glaciers cover ~25 % of the total area of this basin. It hosts seven major valley glaciers of varying length ranging from 5 to 10 km (Kumar et al., 2020) including a few hanging glaciers and cirques (Fig.1). According to glacier inventory (RGI Consortium, 2017), ~74 glaciers having areas from 0.02 km^2 to 33.5 km^2(with an average area of 2.3 km^2) are located in this basin. Among these eight large glaciers (area>5 km^2) cover 72% of total glaciated area. The major concentration of the glaciers feed the east-west flowing stream, while the Raunthi (Bank) glaciers contribute to the northward-flowing Raunthi Gad (Gad - stream).

The Rishi Ganga valley is characterized by recent glacial deposits in the form of moraines. Apart from the moraines, significant amount of debris is available in the form of scree cones emerging from the cirques and slope failures (Fig.1). The channel gradient is steep (10^{-1}), to moderate (10^{-2}) and the average hill slopes ranges from

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Relationship of isotopic variations with spring density in the structurally controlled springs and related geosystem services in Alaknanda Valley, Garhwal Himalaya, India

Aakash Mohan Rawat[1]✉, Dhirendra Singh Bagri[1], Sudhir Kumar[2], Ruchi Badola[3] & Syed Ainul Hussain[3]

As a traditional water source, springs are vital for Himalayan communities and it is essential to consciously focus on springs conservation. We report oxygen isotopes ($\delta^{18}O$) of spring water before, within, and after the tectonically active zones of the Alaknanda Valley, Uttarakhand. Higher variation of $\delta^{18}O$ in the spring waters is found in highly tectonically disturbed zone i.e., Zone-2 with $\delta^{18}O$ range − 4.9‰ to − 9.0‰ compared to tectonically less disturbed zones: Zone-1 and Zone-3 with $\delta^{18}O$ value range − 7.9‰ to − 9.9‰ and − 7.4 to − 10.2‰ respectively. We hypothesize that the highly active thrust zones (Zone-2) with increased permeability compared to other Zones, manifested as greater spring density, results in higher water recharge in Zone-2. Very high to high spring density stretches are dominant in Zone-2 compared to Zone-1 and Zone-3. Stretches in Zone-2 with high spring density formed due to its highly tectonically active nature leads to the higher isotopic variation in Zone-2. The study also identifies the geosystem services provided by thrust zones as water resources to the local people and need of conservation modalities to manage the spring water resources in the thrust zones.

Many accounts associated with the earthquake-induced permeability enhancements and subsequent release of the new water sources have been documented worldwide[1–3]. Further, the coseismic hydrological changes propose the groundwater mixing among different aquifers through new cracks[4], which is the manifestation of the enhanced permeability due to the earthquakes. Stable isotopes of water have been used as proxy[5] to show that that earthquake enhanced permeability and release water from mountains as a subsurface hydrogeological response to the 2016 Mw 7.0 Kumamoto earthquake. The stable isotopic variations have been used as a direct fingerprinting tool to examine the changes in between before and after earthquakes[2,3,6]. On the other hand, the variation in the isotopic ratios ($^{18}O/^{16}O$) of oxygen has generally been attributed to evaporation of meteoric water[7], together with ^{18}O-shift by the water–rock interaction[8] and changes of the oxygen isotopes before earthquakes[9–11]. Also, the isotopic variation with altitude has been worked out by[12,13]. This progressive depletion of the heavier isotope in rain with altitude, as the cloud ascends, is often referred to as the "altitude effect". Thus, most of the studies are focused either on the earthquake or altitude-regulated isotopic variations (altitude effect) or due to the other fractionation processes. Other factors like the very high abundance of springs sources or very high spring density in some stretches and the presence of active thrust zones may also also bring changes in the stable water isotopes giving the indication of water recharge in the zone. As the stable isotopes of oxygen indicate the recharge sources of the water[14–16], the present work has been carried out to understand the impact of tectonics on isotopic composition of spring water.

In the present work, we tried to decipher the first account of the thrust-controlled stable oxygen isotope variation in the spring waters of Alaknanda valley located in Garhwal Himalayas, Uttarakhand, India.

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Identifying potential hotspots of land use/land cover change in the last 3 decades, Uttarakhand, NW Himalaya

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ABSTRACT

Uttarakhand region in the NW Himalaya has experienced two extreme climatic-geomorphic events within last 10 years that killed more than 6000 people. Though these events, like many others in the Himalaya, have been attributed to climate-change and anthropogenic disturbances, identification of potential hotspots of land use/land cover change is rarely attempted to make future inferences for disaster risk reduction. An evaluation of spatio-temporal changes in land use/land cover can be used to identify such hotspots. Therefore, we analysed the spatio-temporal changes in a climatically sensitive and natural disaster-prone area (~28856 km^2) of Uttarakhand (NW Himalaya), India, by comparing the satellite data of years 1991-2020 for ten land use/land cover elements to track the spatio-temporal changes over these years. Results revealed the formation of two hotspots exhibiting relatively more changes in land use/land cover pattern. Though the anthropogenic influence is observed in both hotspots, the influence of spatio-temporally changing climatic parametres is also noted. In view of frequent extreme climatic-geomorphic events, temporally increasing population and tourist pressure, and temporally changing climatic conditions, it is vital to identify hotspots having dominant changes in land use/land cover to understand the possible source of potential disasters.

Keywords: Land use/Land cover; Uttarakhand; Himalaya; Climate; Anthropogenic action.

1.0 INTRODUCTION

The present pattern of infrastructural development and subsequent population increase in the fragile ecosystem in mountain ranges have resulted in increased stress on environment in the form of land use/land cover changes (Paudel et al. 2016). The studies pertaining to the land use/land cover refer to extracting the information about physical characteristics of the earth surface features along with the patterns of their utilization in time and space (Rawat & Kumar, 2015). Change in the land use/land cover is the primary variable that affects a wide

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Paper 1

Himalayan J. Soc. Sci. & Humanities ISSN: 0975-9891
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Socio-economic condition of scheduled castes: A study of Kairana town in Shamli district of Uttar Pradesh

Vinay Kumar Sharma[1]*, Kalish Chandra Purohit[1] and Anita Rudola[1]
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Abstract: India is a nation having multiple languages and religions. Since the time immemorial it has been stratified in various major and minor castes. According to Manu Smriti, there are four main castes, Brahmin, Kshatriya, Vaishya and Shudras. Out of them Shudras are considered of low status and sometimes untouchables. These are generally deprived of basic amenities and education. This paper looks into the various aspects which lead to the low socio-economic status of Scheduled Caste people in Kairana town of Shamli District in Uttar Pradesh. As per Census 2011, the Kairana has a total population of 2,66,121 which includes 18.34% Hindus. Out of the total population of Hindus, there are 5.4% people from Scheduled caste.

Keywords: Occupation, Debt, Backwardness

Introduction

India, a country with multiple and religions is the home for hundreds of castes and sub-castes. This system of caste is not new to it but is prevalent since ancient times and to be precise since the times of Aryans who arrived here from Central Asia as regarded by Carl Marx. Those people had their societies devided into four Varnas namely Brahmins (Learners & Teachers), Kshatriyas (Warriors), Vaishyas (Businessmen) and Shudras (Servants). But these vernas were not decided by birth rather by occupations taken up by people. The people not belonging to any of these categories or say besides these vernas were known as Avarnas or Chandals (Apparaya S. May 2015). As on today these people are known as Scheduled Caste people but this is not because they willingly want to be known so, rather this category has been imposed upon them with no way out. Today we have stepped into the 21st century and we find India highly stratified and discriminatory in terms of castes which are not based upon the occupations but given to people immediately at the time of birth. At present there are approximately more than 3000 castes and sub-castes in India and out of these the condition of scheduled caste people is very pathetic. Generally these people are less educated and have fewer resources due to which they cannot compete with other people and remain in the same class. Due to the lack of resources they are forced to take up such jobs which are of low standard and bring low incomes and lowering their standards of living further down. These people are commonly cobblers, scavengers and washermen etc. These people cannot think of coming out of this web despite having talents as in this society there is no help for them.

The first step towards the upliftment of these downtrodden people was taken during British period through several reforms and by the missionaries who came here to preach people about modernity. The Govt. of India Act 1935 was the first official document to identify the scheduled castes. Several Indian reformers also

Paper 2

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Correlation between sex-ratio and literacy rate in Deoria town: A geographical analysis

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Abstract: This paper is an attempt to analyze the correlation between sex-ratio and literacy rate in Deoria town. Literacy and sex-ratio are two important demographic features of population. Literacy plays an important role in bringing equality in the sex-ratio. In this paper spearman's rank correlation method has been used to analyze the relationship between sex ratio and literacy rate in Deoria town. The study reveals that there is moderate and positive correlation, p=0.014 between sex ratio and literacy rate in the town. It means high literacy rate, high sex ratio. Both variables are independent of each other.

Keywords: Correlation • sex-ratio • literacy rate • Deoria town

Introduction

Literacy means ability to read and write. The United Nations Educational, Scientific and Cultural Organization (UNESCO, 1950) defines literacy as the 'ability to identify, understand, interpret, create communicate and compute using printed and written materials associated with varying context.' According to census of India, a person aged seven years or more than seven years who can read and write with understanding in any language is called a literate person. Any form of education or minimum educational standard is not necessary to be considered literate. Literacy is quite necessary for eradicating poverty and mental isolation. Generally, literacy levels are high in developed countries. Urban areas have higher literacy than rural areas. The economic and social development of a country depends to a great extent on the literacy levels of its population.

Sex ratio is the ratio of males and females in a population. Sex ratio is used to describe the number of females per 1000 of males which is a valuable source for finding the population of women in India. It is an important social indicator to measure the extent of prevailing equality between males and females in a society. In population census of 2011, it was revealed that the sex ratio in India is 940. The sex ratio (2011) shows an upward trend from census of 2001 (933). Over the span of more than 100 years the deficit of women has progressively increased as evident from the sex ratio of population (Visaria, 1972).

Study Area

Deoria town was declared the district headquarter of Deoria district on 2nd October 1946. It was formerly the eastern part of Gorakhpur district. The town

Paper 3

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Populaion Characteristics of Village Thein of Kathua District (Jammu and Kashmir)

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Abstract: The present paper seeks to mirror the population feature of a village of Kathua district of Jammu and Kashmir. For the purpose a micro-level door-to-door survey was conducted in the year 2016, which included a number of questions pertaining to the theme. The results at village level study have been found to be quite different but are accurate. The figures related to various characteristic of population vary greatly from one religious, community to another

Key word: Resource, Migration, Occupational Structure, Physico-Culture

Introduction

Population studies happen to be an important part of geographical interpretation of an area. Population geography deals with the relation of population to its land in terms of both quality and quantity. In the study of population, the main task is the measurement of population parameters. Modern geographers consider the human population as a resource. In fact, resourcefulness of the physical element depends upon the capacity of inhabitants to utilize them for satisfying their needs (Zimmerman, 1964). Population is the point of reference from which all other elements are observed and from which they all singly or collectively derived significance and meaning (Trewartha, 1953). Man is the geographical agent who modifies the surroundings through his actions and brings changes in it. The man-nature relations have undergone a drastic change overtime as per changing time and conditions.

Geographical conditions have had a direct control on the climate, vegetation, soil, drainage, minerals, etc., thereby affecting the spatial distribution of population on the globe. The growth, density, sex ratio, age- structure, occupational structure, literacy, rural- urban structure and migration- all are variable from one place to another due to a number of physio- cultural factors.

The study area

For the purpose in hand, village Thein of Jammu & Kashmir has been chosen. This village is situated in Basholi Block of Kathua district along the national Highway between Lakhanpur and Basholi, at 32° 24' N Lat and 75° 41' E Long (Figure 1), with an area of 1585 acres surrounded by the villages Dannor, barrah and Danna. The topography of Kathua district is variable occupying high mountains, valleys, outer plains (S.W.) ranging from 280-500 meter elevation. The village is situated at predominant plain of the Shivalik ranges. The climatic conditions are influenced by physiographic conditions and the plain areas experience very hot during summers where temperature reaches 48°C. The entire district is profusely drained by numerous ephemeral and small perennial streams. Thein village is mainly drained by the river Ravi. The 'Ranjit Sagar' Dam on this river is popularly known as Thein /dam. Thein was also declared as Wildlife Conservation Reserve by the government in 1981.

Paper 4

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व्यावसायिक संरचना में परिवर्तन : गढ़वाल जनपद के विशेष सन्दर्भ में

• हरिमोहन भण्डारी
••अनिता रतूड़ोला, ••• के.सी. पुरोहित

सारांश- *व्यवसाय जीविका की प्राप्ति तथा एक निश्चित सामाजिक स्तर को बनाये रखने के उद्देश्य से व्यक्ति द्वारा अपनायी गयी सतत् क्रिया होती है। व्यवसाय वह विशिष्ट आर्थिक क्रिया है जिससे कोई व्यक्ति अपनी जीविका प्राप्त करता है। अतः सभी आर्थिक क्रियायें व्यवसाय का अंग हैं। किसी क्षेत्र की व्यावसायिक संरचना का अध्ययन करने से उस क्षेत्र के सामाजिक-आर्थिक विकास के स्तर की जानकारी प्राप्त होती है। प्रस्तुत अध्ययन का मुख्य उद्देश्य जनपद में महिलाओं तथा पुरूषों का विभिन्न व्यवसायों में भागीदारी का अध्ययन करना है। गढ़वाल जनपद की कुल जनसंख्या (6,87,271) में से 5,74,568 ग्रामीण जनसंख्या है। ग्रामीण जनसंख्या की कुल जनसंख्या में से 23.46 प्रतिशत जनसंख्या मुख्य कार्यशील जनसंख्या तथा 18.45 प्रतिशत सीमान्त कार्यशील जनसंख्या है। शेष 58.09 प्रतिशत अकार्यशील जनसंख्या का है। लिंगानुपात के आधार पर जनपद के 28.69 प्रतिशत पुरूषों तथा 18.89 प्रतिशत महिलायें मुख्य कार्यशील जनसंख्या को प्रदर्शित करते है। सीमान्त कार्यशील जनसंख्या में पुरूषों तथा महिलाओं का प्रतिशत क्रमशः 15.98 व 20.60 है। सीमान्त कार्यशील जनसंख्या में पुरूषों की अपेक्षा महिलाओं का प्रतिशत अधिक है और यही प्रवृति विकासखण्डों में भी देखने को मिलती है।*

मुख्य शब्द– व्यवसाय, आर्थिक क्रियायें, सामाजिक–आर्थिक विकास, मुख्य कार्यशील, सीमान्त कार्यशील, अकार्यशील।

प्रस्तावना– व्यवसाय की संरचना एक गत्यात्मक विचार है, जो देश काल के अनुसार परिवर्तित होती है। आधुनिक समाज में श्रम विभाजन, कार्यात्मक विशिष्टीकरण, परिवर्तन की नवीन विधाओं तथा प्रचलित विचारधाराओं के प्रभाव से युक्त अधिकांश जनों का अपनी जीविका की प्राप्ति तथा एक निश्चित सामाजिक स्तर को कायम रखने हेतु एक

Paper 5

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उज्याड़ी गाँव (उत्तराखण्ड) की साक्षरता दर में परिवर्तन का अध्ययन

• हरिमोहन भण्डारी
•• के.सी. पुरोहित, •••अनिता रूडोला

सारांश- साक्षरता का शाब्दिक अर्थ है व्यक्ति के साक्षर (अक्षर युक्त) होने का गुण। सामान्य अर्थ में साक्षर वह व्यक्ति है जो किसी भाषा में पढ़ना और लिखना जानता है। अक्षर ज्ञान साक्षर होने के लिये अनिवार्य है। साक्षरता मनुष्य के सोच विचार और कार्य करने की योग्यता में वृद्धि करती है और उसे नवीन खोजों की दिशा में प्रवृत करती है, जिससे सामाजिक आर्थिक एंव सांस्कृतिक प्रगति का मार्ग प्रशस्त होता है। समाज में व्याप्त अन्धविश्वास, रूढ्विादिता, धार्मिक कट्टरता, सामाजिक भेदभाव, निर्धनता आदि को दूर करने में साक्षरता का महत्व सर्वोपरि है। भारत के सन्दर्भ में शिक्षा और साक्षरता में कुछ भौतिक अन्तर है जो व्यक्ति कम से कम किसी एक भाषा में पढ़ना और लिखना जानता है तथा अपना हस्ताक्षर बना लेता है, उसे साक्षर माना जाता है जबकि शिक्षा के लिये पाठशाला उत्तीर्ण करना भी आवश्यक होता है। प्रस्तुत अध्ययन से यह निष्कर्ष निकलता है कि उज्याड़ी गाँव में साक्षरता का स्तर निम्न है जिसमें महिला साक्षरता का प्रतिशत बहुत कम है। साक्षरता में वृद्धि की प्रवृति देखने को मिलती है। 2011 की जनगणना के अनुसार उज्याड़ी गाँव की कुल साक्षरता दर 73.36 प्रतिशत है जिसमें पुरूष साक्षरता 80.72 प्रतिशत जबकि महिला साक्षरता 66 प्रतिशत है।

मुख्य शब्द– साक्षरता, अन्धविश्वास, रूढ़िवादिता, सामाजिक भेदभाव, निर्धनता, साक्षर।

प्रस्तावना– साक्षरता वह वैयक्तिक गुण है जो किसी व्यक्ति के पढ़ने और लिखने की योग्यता को प्रकट करती है। साक्षरता मनुष्य के सोच विचार और कार्य करने की योग्यता में वृद्धि करती है और उसे नवीन खोजों की दिशा में प्रवृत करती है, जिससे सामाजिक आर्थिक एवं सांस्कृतिक प्रगति का मार्ग प्रशस्त होता है (आर सी चान्दाना 1980)[1]। समाज में व्याप्त अन्धविश्वास, रूढ़िवादिता, धार्मिक कट्टरता, सामाजिक भेदभाव, निर्धरता आदि को दूर करने में साक्षरता का महत्व सर्वोपरि है। मानव सभ्यता का विकास प्रत्यक्ष रूप से साक्षरता से सम्बन्धित रहा है और वर्तमान काल में वे देश या प्रदेश आर्थिक रूप से अधिक समृद्ध हैं जहाँ साक्षरता दर उच्च, एवं वे देश पिछड़े हुये हैं जहाँ साक्षरता दर निम्न है। इतना ही नहीं साक्षरता का विभिन्न जनाकिंकीय पक्षों- जन्मदर, मृत्युदर, प्रवास,

Paper 6

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S.N. - 0975-4903

भूमि उपयोग एवं भूमि आवरण का बदलता स्वरूप तथा इसके प्रभाव : शाहजहाँपुर जनपद का एक प्रतीकात्मक अध्ययन

हरीश कुमार राठौर, अनिता रूडोला एवं बी0एल0 तेली

शोध सारांश

भूमि उपयोग भौगोलिक अध्ययन का प्रमुख पक्ष है। सामान्यता भूमि शब्द का तात्पर्य अनेकानेक सम्भावनाओं से युक्त शाश्वत व अनश्वर भूखण्ड से है जिसका स्वरूप मानव की आवश्यकताओं के परिप्रेक्ष्य में कालक्रम के अनुरूप परिवर्तनशील गुणों से युक्त है, जबकि उपयोग शब्द कालिक प्रक्रिया की ओर इगिंत करता है। प्रस्तुत शोध अध्ययन का क्षेत्र जनपद शाहजहाँपुर है जो रूहेलखण्ड सम्भाग में फैला है। कृषि की दृष्टि से यह क्षेत्र उपयुक्त है। पर्याप्त भूमि उपलब्धता के फलस्वरूप सकल प्रतिवेदित क्षेत्र के 80.30 प्रतिशत भाग पर कृषि की जाती है। सकल बोये गये क्षेत्र में 51.19 प्रतिशत रबी, 48.85 प्रतिशत खरीफ एवं 1.96 प्रतिशत जायद की फसल के अन्तर्गत है। कुल कृषि भूमि का 91.60 प्रतिशत सिंचित है तथा सिंचाई गहनता 188 प्रतिशत है। तीव्र गति से बढ़ती जनसंख्या एवं अनियोजित तरीके भूमि प्रयोगिक कारण प्रति व्यक्ति भूमि का क्षेत्रफल दिनोंदिन कम होता जाता है। अध्ययन क्षेत्र में ऊसर, बंजर, अनुपजाऊ एवं परती भूमि को सिंचाई सुविधाओं एवं कृषि तकनीकी प्रयोग के द्वारा कृषि क्षेत्र को बढ़ाया जा सकता है।

प्रस्तावना

भूमि संसाधन आर्थिक क्रियाओं का आधार है। जीविकोपार्जन का मुख्य स्त्रोत भूमि ही है। कृषि की दृष्टि से भूमि का समतल होना, जल संसाधनों की उपलब्धता एवं भौगोलिक परिस्थितियों के आधार पर कृषि प्रारूप प्रभावित होता है। उत्पादन वृद्धि के लिए कृषि योजना बनाने हेतु भूमि उपयोग का अध्ययन जरूरी है। यही नहीं भूमि उपयोग प्रतिरूप का आर्थिक एवं सामाजिक समस्याओं के समाधान एवं क्षेत्रीय विकास में महत्वपूर्ण योगदान होता है। इसके साथ ही साथ क्षेत्र विशेष की पहचान भूमि उपयोग के स्वरूप से ही दृष्टिगत होती है। भूमि पौधों और अन्य जीवों के लिए जल और अन्य पोषक तत्वों के भण्डार के रूप में कार्य करती है। खाद्य, ऊर्जा और अन्य मानवीय आवश्यकताओं की मांग भूमि की उत्पादकता के संरक्षण और सुधार पर निर्भर करती है। सर्वविदित है कि भूमि उपयोग भूमि की शोशण प्रक्रिया है जिसमें भूमि का व्यावहारिक प्रयोग किसी निश्चित उद्देश्य के लिए किया जाता है। भूमि उपयोग का प्रभाव मानव जीवन के लिए महत्वपूर्ण है। मानव के अधिकांश कार्य भूमि पर तथा भूमि के माध्यम से ही संचालित होंते है। भूमि संसाधनों का उपयोग विविध प्रकार से मानव की विभिन्न आवश्यकताओं को सन्तुष्ट करने के लिए किया जाता है। मनुष्य की आवास, भोजन, आवागमन हेतु संचार साधनों ईंधन, फल, फूल, सब्जी इत्यादि अनेक आवश्यकताओं की परिपूर्ति भूमि पर ही निर्भर है।

अध्ययन क्षेत्र

प्रस्तुत शोध–पत्र का अध्ययन क्षेत्र शाहजहॉपुर जनपद है जो रूहेलखण्ड भौगोलिक क्षेत्र का एक अभिन्न अंग है। जनपद शाहजहॉपुर का अंक्षाशीय विस्तार 27°, 35′ उत्तरी अंक्षाश से 28°, 29′ उत्तरी अंक्षाश एवं देशान्तरीय विस्तार 79°, 37′ पूर्वी देशान्तर से 80°, 23′ पूर्वी देशान्तर के

1. हरीश कुमार राठौर, शोध छात्र, भूगोल विभाग, हेमबती नन्दन बहुगुना गढवाल विश्वविद्यालय पौड़ी परिसर, गढवाल।
2. डा0 अनिता रूडोला एवं प्रो0 बी.एल. तेली, भूगोल विभाग, हेमबती नन्दन बहुगुना गढवाल विश्वविद्यालय, पौड़ी परिसर, पौड़ी गढवाल, उ0ख0।

Paper 7

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Correlation between sex –ratio and literacy rate of the urban centers in district Pilibhit

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Abstract: Literacy and sex ratio is an important element of cultural and biological composition of population. Generally literacy is defined as the ability to read and write. Sex ratio is defined as the number of females per thousand males. It depends on rate of birth, death and migration. The sex ratio is found less due to negligence of girl child, early marriage, preference for male child etc,. Sex ratio in our country since long period had remained unfavorable to females. The main objectives of the present paper are to study the correlation between the literacy and sex ratio of urban centers in District Pilibhit. The present work is based on secondary sources of data and collected from census of India 2011. The two variables i.e. literacy and sex ratio of urban centers in District Pilibhit has been taken into consideration for the study. The data is processed and calculated correlation between literacy and sex ratio by using Spearman's rank correlation method.

Keywords: Correlation, Sex-Ratio, Literacy, Pilibhit, Urban Centers

Introduction

Literacy and Sex Ratio are two important demographic characteristics of population. Literacy involves in cultural composition and sex ratio is discussed under biological composition (Ghosh, 1985.). Literacy means the ability to read and write with certain understanding. The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines literacy as the "ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts.

Sex ratio means the ratio between males and females in the total population. It is defined as the number of females per thousand males in a population. It affects on labour supply, age of marriage, population growth, status of women etc. It is an important attribute of demography and is influenced by birth, death and migration.

Objectives

(i) To study the change of literacy rate and sex ratio in the study area.
(ii) To examine correlation between literacy and sex ratio in the study area.

Methodology

The study is based on secondary data regarding literacy rate and sex ratio of town areas of district Pilibhit which obtained by census of India 1991-2011.The methodology adopted to achieve the aim is Spearman's correlation relationship between literacy rate and sex ratio.

Paper 8

जनपद शाहजहाँपुर में भूमि उपयोग एवं नियोजन एक भौगोलिक अध्ययन

-डॉ० अनिता रूडोला
भूगोल विभाग

-प्रो० बी०एल० तेली
भूगोल विभाग

-हरीश कुमार राठौर
भूगोल विभाग
एच० एन० बी० गढ़वाल विश्वविद्यालय
पौड़ी परिसर, पौड़ी गढ़वाल, उत्तराखण्ड

भौगोलिक सन्दर्भ में 'भूमि' की परिभाषा धरातल, वायुमण्डल और समुद्र के त्रिविम रूप में की जाती है। भूमि का यह व्यापक अर्थ न केवल धरातल, जल एवं हिम आदि को ही व्यक्त करता था, बल्कि यह भवनों खेतों, खनिज संसाधनों, जल संसाधनों, वायु संसाधनों के गुणों को समाहित करता है, जैसे हवा और सूर्य प्रकाश, वर्षा, पवन, तापमान, वाष्पन इत्यादि। ये सभी किसी न किसी प्रकार के भूमि उपयोग को प्रभावित करते हैं। भूमि के अन्तर्गत ऐसे सुधार और विकास भी सम्मिलित किए जाते हैं, जो मनुष्य द्वारा विकसित किए गए हैं और धरातल को प्रभावित करते हैं तथा जिन्हें हम आसानी से भूमि से पृथक नहीं कर सकते है। मनुष्य द्वारा निर्मित किए गये गुण सामान्यत: प्रकृति के गुणो के समान ही व्यवहार करते हैं, जैसे मनुष्य द्वारा समतल की गई भूमि भी प्रकृति द्वारा प्रदत्त समतल भूमि के समान ही गुणों एवं लक्षणों से युक्त होती है। इसी प्रकार पौधों में दिए जाने वाले मानव निर्मित पोषक पदार्थ भी प्रकृति द्वारा प्रदत्त पोषक पदार्थो की भांति कार्य करते हैं और लाभप्रद सिद्ध होते है। भूमि संसाधन को धरातल की मौलिक दशाओं से प्राप्त साधनों और मानव कल्याण के लिए उसकी सन्निहित विशेषताओं के रूप में परिभाषित किया जा सकता है। इसी प्रकार भूमि संसाधन धरातल पर मनुष्य द्वारा किये गये सभी विकासों को अपने में समाहित करता है। अब यह संकुचित अर्थ का प्रयोग नहीं रह गया है जो प्रकृति द्वारा प्रदत्त संसाधनों को ही अपने अन्दर ग्रहण करता है।

अध्ययन क्षेत्र :-

प्रस्तुत शोध-पत्र का अध्ययन क्षेत्र गांगेय मैदान में विस्तृत जनपद शाहजहाँपुर हैं। भौगोलिक दृष्टि से रुहेलखण्ड भौगोलिक क्षेत्र के पूर्वी भाग में स्थित है जिसका अंक्षाशीय विस्तार 27°, 35' उत्तरी अंक्षाश से 28°, 29' उत्तरी अंक्षाश एवं देशान्तरीय विस्तार 79°, 37' पूर्वी देशान्तर से 800, 23' पूर्वी देशान्तर तक फैला है। इसका कुल क्षेत्रफल 4575 वर्ग किलोमीटर हैं। अध्ययन क्षेत्र की पूर्वी सीमा लखीमपुर खीरी एवं हरदोई जनपदों एवं पश्चिमी सीमा का निर्धारण बरेली एवं बदायूँ जनपदों द्वारा निर्धारित हैं। इसके उत्तर में जनपद पीलीभीत और दक्षिण में फर्रूखाबाद जनपद द्वारा घिरा हुआ है। वर्ष 2011 की जनगणना के अनुसार कुल जनसंख्या 30.06 लाख व्यक्ति है तथा जन घनत्व 657 व्यक्ति प्रति वर्ग किलोमीटर है।

अध्ययन के उद्देश्य :-

जनपद शाहजहाँपुर एक समतल कृषि प्रधान क्षेत्र है। यहाँ की कृषि में भूमि उपयोग का स्थान मुख्य है। तीव्र गति से बढ़ती हुई जनसंख्या के फलस्वरूप यहाँ पर खेतिहर भूमि में निरन्तर कमी आ रही है किन्तु तीव्र गति से बढ़ते मशीनीकरण के प्रयोग एवं कृषि क्षेत्र कृषि से अतिरिक्त खाद्यान्न उत्पादन की अभिरूचि के कारण कृषि के अन्तर्गत

Paper 8

भारत में थारु जनजाति का सामाजिक-आर्थिक स्वरूप : एक भौगोलिक विश्लेषण

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सारांश :-

भारत में थारू समाज का रहन-सहन, खान-पान, पहनावा, आर्थिक क्रिया-कलाप, कला एवं संस्कृति पर्यावरण के बेहद अनुकूल है आज भी इनके समाज में संयुक्त परिवार प्रथा विद्यमान हैं। पित्रशत्तात्मक समाज होने के बावजूद भी महिलाओं को घर के विशेष निर्णयों को लेने का पूर्ण अधिकार है। इस समाज की विडम्बना है कि ये लोग स्वयं तक ही सीमित है जिस कारण इनकी अर्थव्यवस्था एक 'बंद अर्थव्यवस्था' का अच्छा उदाहरण है। यह जनजाति कई उपजातियों में विभक्त है इनका निवास क्षेत्र मुख्यत: उत्तराखण्ड, उत्तर प्रदेश तथा बिहार राज्य में है। भारत में इनकी कुल जनसंख्या 3.56 लाख है। इस समाज के युवाओं में विलक्षण प्रतिभाएँ विद्यमान है जो शिक्षा, तकनीकि कौशल तथा संचार के साधनों के माध्यम से पूर्णतय: विकसित की जा सकती है बसरते उनकी प्राचीन संस्कृति को हानि न पहुँचे ।

Key Word–थारू समाज, आर्थिक क्रिया-कलाप, निवास क्षेत्र, विशेषताएँ, समस्याएँ।

प्रस्तावना :-

भारत के समाजिक संगठन में विभिन्न सामुदाय समूहों, जातियों एवं जनजातियों का विशेष योगदान है। इनमें से जनजातियाँ सबसे प्राचीन हैं जो बीहड़ जंगलों, ऊँचे पहाड़ों व दुर्गम स्थानों पर निवास करती हुई प्रकृति के साथ जीवन का एक सन्तुलन बनाए हुए है। सभ्य समाज भले ही इन्हें असभ्य, जंगली व पिछड़ा आदि नामों से पुकारे पर ये सीमित संसाधनों में भी प्रकृति के साथ अपना जीवन व्यतीत कर रही है। इन्हीं में से 'थारू' जनजाति भी एक है।

'थारू' शब्द की उत्पत्ति और अर्थ के सम्बन्ध में कई विचार प्रस्तुत किए गए है। परन्तु 1847 में बंगाल एशियाटिक सोसायटी के जर्नल जे० एस० गेम्बलन ने लिखा है कि जंगलों में रहने वाले लोग 'थरना' नामक शब्द का प्रयोग करते है जिसका अर्थ है 'परिभ्रमण' करना। अत: थारू शब्द इसी का पर्यावाची है। क्योंकि इनके सम्बन्ध में लिखित प्रमाण नहीं मिलते है फिर भी अधिकांश विद्वान इन्हें थारमरूस्थल का निवासी मानते है जो राजाओं के यहाँ सेवक का कार्य करते थे। मुगल आक्रमण के समय ये राजाओं के आदेशानुसार रानियों को लेकर वनों की ओर चले गये और युद्ध में राजाओं के पराजित हो जाने के कारण ये वापस नहीं लौट सके। राज्य परिवार की कन्याओं ने इनसे विवाह कर लिया तथा इनसे उत्पन्न संतानें थारू कहलाई। थारू जनजाति भारत-नेपाल सीमावर्ती तराई क्षेत्र में निवास करने वाली प्रमुख जनजाति है। जनगणना, 2011 के अनुसार भारत की कुल थारू जनसंख्या 3,56,572 है जो भारत की कुल जनजातीय जनसंख्या का मात्र 0.34 प्रतिशत है। नेपाल में इनकी जनसंख्या 17.37 लाख है जो नेपाल की

Paper 10

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चमोली जनपद में भोटिया जनजाति की महिलाओं का सामाजिक एवं जनांकिकीय परिवर्तन

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सारांश

प्रस्तुत शोध कार्य चमोली जनपद में स्थित भोटिया जनजाति की महिलाओं की सामाजिक एवं जनांकिकीय परिवर्तन को प्रदर्शित करत है। हमारे समाज में महिलाओं की स्थिति सदैव ही अच्छी नहीं रही है ;यद्यपि वर्तमान समय में इसमें बहुत तेजी से परिवर्तन आ रहे हैं। और य स्थिति पहाड़ी क्षेत्रों के सन्दर्भ में और अधिक गम्भीर हो जाती है। पहाड़ी क्षेत्रों में महिलाओं को घर के काम के अलावा कृषि कार्य और पशुपाल के कार्यों में अपना समय देना होता है। जिस कारण शारीरिक रूप से उनकी स्थिति बहुत ही कमजोर हो जाती है। इसके अतिरिक्त उन्हें सम्पू आहार भी नहीं मिलता जिस कारण वे कुपोषण का शिकार हो जाती है। परन्तु वर्तमान समय में शिक्षा के बढ़ते प्रभाव के कारण गांवों से पलाय बहुत तेजी से हो रहा है जिस कारण महिलाओं के कार्य प्रतिरूप में बहुत तेजी से बदलाव आ गया है। अब महिलाऐं घरेलू कार्य के अतिरिक्त रोजगार परक कार्यों में अधिक रूचि ले रही हैं। पलायन के कारण भोटिया जनजाति की महिलाऐं भी अपने कार्य स्वरूप को तेजी से बदल रह है और विभिन्न तृतीयक एवं चतुर्थक व्यवसायों में अपना योगदान दे रही हैं।

भोटिया जनजाति उत्तराखण्ड की अति प्राचीन और महत्वपूर्ण जनजाति है। सन 2001 की जनगणना के अनुसार उत्तराखण्ड में भोटिय जनजाति की जनसंख्या 36422 है जो प्रदेश की कुल जनजाति का 14,22 प्रतिशत है उत्तराखण्ड के गढ़वाल मण्डल के उत्तर काशी तथ चमोली जिलों में भोटिया जनजाति अपनी विशिष्ट सभ्यता तथा संस्कृति को पहचानी जाती है। इनके ग्राम समुद्र तल से 10,000फीट से भ अधिक ऊचाई पर स्थित है। भोटिया जनजाति भारत सरकार दवारा अनुसूचित जनजाति के रूप में मान्यता प्राप्त है।

प्रस्तावना भोटिया जनजाति उत्तराखण्ड की अति प्राचीन और महत्वपूर्ण जनजाति है। सन 2011 की जनगणना के अनुसार उत्तराखण्ड भ भोटिया जनजाति की जनसंख्या 12260 हैं। जो कि प्रदेश की कुल जनजातियों का 313 प्रतिशत हैं। उत्तराखण्ड के गढ़वाल मंडल के उतरकाशी तथा चमोली जनपदों में भोटिया जनजाति अपनी विशिष्ट सभ्यता तथा संस्कृति को समेते हुए सदियों से निवास करती आ रही है। मध्य हिमालय के कुमाउँ और गढवाल मंडलों के उतरी भाग का लगभग 4000 वर्ग मील का श्रिभुजाकार क्षेश्र इनके नाम पर भोटिया प्रदेश के नाम से जान जाता है। भोटिया लोगों का निवास नदियों के तटों पर है। क्योंकि इस क्षेश्र का अधिकांश भाग पथरीला व धरातलीय दष्टि से उबड खाबड है। भोटिया जनजाति की उत्पति के सम्बन्ध में अलग अलग विद्धानों के विचार अलग अलग है। पौराणिक साहित्य में वर्णित आधार पर ज्ञात होता है। कि आज से लगभग 4000 वर्ष पूर्व हिमालय के इस क्षेश्र में मध्य एशिया को छोडकर तिब्बत मार्ग से कुणिन्द किरात दाध खस आदि जातियों पहुँची थी। इन्हीं जातियों ने क्षेश्र को उपयुक्त समझकर यहाँ स्थायी रूप से रहना प्रारम्भ कर दिया।इसी प्रकिया में भोठिया जनजाति ने भी यहाँ निवास करना प्रारम्भ किया।

भोटिया जनजाति में तीन वर्ग पाये जाते है। मारछा तथा जाड। इनमें से मारच्छा किरात वंशी है। तोलच्छा अन्य जातियों जैसे खस किरात तथा बाहर से आए लोगों के संसर्ग से बनी है। इससे भी इस बात की पुष्टि होती है कि मूल भोटिया लोगों की उत्पति तिब्बती मार्ग से आने वाले मध्य एशिया के लोगों से हुई है।

अध्ययन क्षेत्र

प्रस्तुत शोध कार्य के लिए उतराखण्ड राज्य में स्थित चमोली जनपद के 09 गांवों का चयन किया गया है।(चित्र संख्या 1) इन गांवं का चयन उद्देश्य परक प्रतिदर्श के आधार पर भोटिया जनजाति की जनसंख्या को सूचित कर किया गया है।

Paper 11

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Local Residents' Perception about Potential Components of Community Based Tourism in Chamoli District of Garhwal Himalaya

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Abstract: Chamoli district is the land of various natural and cultural tourism spots and well known for Badrinath (one from the four Dhams) heritage, craft and tremendous natural beauty. Chamoli has the possession on various snow-capped lofty mountain peaks which attracts the tourists and endow with natural splendor. Visitors can get pleasure from culture, customs, costumes, cuisines, dialects and music in the form of community-based tourism as Chamoli is blessed with tremendous culture. This study assesses the perception of local residents about potential components to develop community-based tourism (CBT) in Chamoli district. The qualitative and quantitative technique has been used to collect the data. The results found that perception of communities, for the fact of traditions, uniqueness, and handling of tourism products is a bit negative but overall perception is positive that is very helpful and important to develop as well as enhance CBT in Chamoli district.

Key words- Community based tourism, Potential, Culture, Components

Introduction

Tourism is the most rapidly growing industries worldwide. According to the World Tourism Organization, international tourism is growing at a rate of approximately 4% per year WTO (2000). As a result of the environmental concern, dissatisfaction is emerging for the mass tourism among the people which led to an increase demand of rural tourism. According to Honey (2008), Community-based tourism is a safe means of earning livelihood through a less destructive use of local resources. Rural areas, which are culturally and traditionally rich, are the main centers of community-based tourism (Mallya, 2006). These days, CBT is essential for the sustainable development as well as it strengthens the local economy. In reference of India, it is said that the country has not reached at par with the neighboring countries (Hai & Chik, 2011). Pilgrimage tourism in Chamoli District attracts more tourists rather than the other forms of tourism. Though, it has vast potential to attract visitors of every form and be a significant source of earning of the associated population (Gupta & Bhatt, 2015). In the field of community based tourism, researches revealed that only a very small population is concerned to this form of tourism and the reason behind it is the seasonal tourism activities in this area. However, governments as well as local agencies are working to promote the community based tourism. It is very helpful to conserve and sustain the local resources with the growth of local economy. With the enhancement of the economy there is a need of the planned tourism so that it brings other benefits for the communities (Haque & Aich, 2014).

The present study acknowledges the fact that identifying local community's perceptions about the components which support the CBT in the area and enhance the quality of the tourism products. Hence, the results of the present study may be used to reorganize the tourism products and simulate the model for tourism growth (Folke et al., 2002; Walker et al., 2002). The residents' perceptions of recreational

Paper 12

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01

POPULATION AND URBAN SPRAWL IN LUCKNOW CITY: PROBLEMS & PROSPECTS

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Abstract: *An unprecedented population growth and migration, and increased urban population and urbanization are inadvertent. These urban ecosystems are a consequence of urbanization through rapid industrial centers and blooming up of residential colonies, also became hub of economic, social, cultural, and political activities. Urbanization, as such, is not seen as a threat to the environment and development, but it is the unplanned urbnization and subsequent urban growth, or the sprawl that affects the land-use of any region prone to extensive urbanization with loss of prime agricultural lands. Therefore there are certain demorgaphic, physical, economic, social and environmetnal and lastly governance factors which contribute to this phenominon of sprawl. Ideally, the growth that takes place around urban areas should be channeled in an orderly manner that will produce an economically efficient, socially and personally satisfying living environment. In practice, ideal growth can hardly be achieved due to many practical reasons. But, it can be said that growth is a phenomenon, it can be guided to prevent it from becoming sprawl.*

Key words: Urban sprawl, Urban-rural fringe, Migration trend, LU/LC change, GIS

Introduction

In industrial countries the future growth of urban populations will be comparatively modest since their population growth rates are low and over 80 percent of their population already live in urban areas. Conversely, developing countries are in the middle of the transition process, when growth rates are highest. The transition drifts from agricultural employment, high overall population growth and increasing urbanization rates. In the initial stages, development in the form of service centers such as shops, cafeteria etc. is seen on the roadside, which eventually become the hub of economic activities leading to sprawl. This type of upsurge caused by a road network between urban / semi-urban / rural centers is very much prevalent and persistent in most places in India. Biggest challenge is to ensure adequate housing, sanitation and health, and transportation services in a habitable urban environment in developing countries. Sprawl is seen as one of the potential threats for such developing and for better management of resources in developing country. Hence, it is very essential to understand the phenomenon of urban sprawl.

Literature Review

There are so many studies done by Geographers, Planners, and Scientists & Researchers in the concerned study area. Er. Rajeev Shekhar et al. prepared a land use land cover map of the concerned area. Swadesh Kumar et al. (2013) also described the assessment of land use around highly populous business centre. Another study done by Pathak et al. (2009) he described that the issues arising from unplanned and rapid urban growth, developing countries could significantly gain from the information generated using advanced technologies such as satellite Remote Sensing, Geographical Information System (GIS), Global Positioning System

Paper 13

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Directions of Urban Growth: Spatio-Temporal Analysis of Lucknow City

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Abstract

Urban growth refers to the physical expansion of the cities and towns due to population growth and migration which is called urbanization. It is a global phenomenon in developing countries like India, where the population is over one billion, we can say one-sixth of the world's population. This type of growth is affected agriculture land and also surrounding habitation. So many cities formulated development plans. Geographers, planners, scientists require information about to the population growth rate, pattern and extent of expansion of city. In the lacking of this type of information, most of the growth areas lacking of basic amenities and infrastructure facilities.

This study represents the sprawling of the Lucknow city has led to the change land use at the urban fringe and the surrounding rural hinterland since many years ago. The population growth in the core area of the city finally resulted in out migration of population from city centre at the urban-rural fringe. The land use and land cover change is a natural process and cannot be stopped but it can be controlled to minimize the harmful impacts of urban growth on environment and resources. Physical expansion and pattern of growth can be detected with the help of ancillary and temporal data. Geographic Information System (GIS) provide the advance techniques and methods to the study of urban growth for sustainable development.

Keywords: *Urban growth pattern & direction, Urban-rural fringe, LU/LC change, GIS*

Introduction

India has only 2% of global land and 4% of water, but it has 16% of the population of the world. Urbanization is an indicator of the level of development of any region. The phenomenon of urbanization depends solely on the resource base of any region. In 1947, there were only 3 cities above a million populations i.e. Chennai, Kolkata and Mumbai. Today these numbers have grown rapidly to 53 Urban Agglomerations in 2011 from 35 Urban Agglomerations in 2001. Statistics show that 18.8 percent of urban population in 1951 has risen to 27.8 percent in 2001 to and further to 31.16% in 2011. The number of census towns has increased form 1362 in 2001 to 3894 in 2011. An unprecedented population growth and migration, and increased urban population and urbanization are inadvertent. These urban ecosystems are a consequence of urbanization through rapid industrial centers and blooming up of residential colonies, also became hub

Paper 14

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IMPACT OF GROWTH AND DENSITY OF POPULATION ON DEMOGRAPHIC STRUCTURE OF DISTRICT ALLAHABAD (U.P)

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Abstract: India is the second-largest populous country in the world. Population plays a vital role in any country. India is not only rich in natural resources but also blessed with human resources. Population growth of any area is an index of economic development, cultural background, historical event, social awakening and political ideology. In our country, the population increased at a rapid rate. This paper deals with population characteristics of the Allahabad district which mainly includes the growth of population and population density of Allahabad district. This paper is purely based on secondary data of Census 1991, 2001, and 2011 and shows the data through charts and graphs.

Keywords: Population Growth, Density, Natural resources.

Introduction

Population growth and its distribution involve two key issues in any population studies (Rubenstein 2010). The concept of growth of population is often used to connote in the number of inhabitants of territory during a specific period, irrespective of the fact whether the change is negative or positive (Chandana, 2008). Population growth is an aspect of the population that is most often discussed not only by the demographer but also by people concerned with economic growth, national planning and social welfare. It refers to the change in population size (increase or decrease) between two decades (Mishra, 1980, pp, 128). The population growth patterns that we observe around the world are not the same. We can roughly divide the world into two broad regions, namely, the Developed World and the Developing World. Most of the population originate in the developing world which represents over 80% of the world's population (Newbold, 2017)

The growth of population in an area is the index of its economic development, social awakening and many other characteristics (Bajaj, 1963). The spectacular acceleration in population growth was the product of the decline in mortality and the widening gap between birth rate and death rate (Chandana, op.cit.). The death rate declined in the developing countries after the Second World War due to the large scale application of improved medical and health technology and significant improvement in food production. On the other hand, the urban centre, particularly the big industrial centres were recording rapid population growth.

Study Area: Allahabad District is the most populous district in Uttar Pradesh. The district Allahabad is situated in the Gangetic Plain. The geographic area of Allahabad district is 5482 km². It extends from 24° 47' to 25° 47' north latitude and from 81° 19' to 82° 21' east longitude (Fig 1). Its peripheral boundaries extend in the north to Jaunpur and Pratapgarh districts, in the south to Rewa district of Madhya Pradesh, in the west to Fatehpur and Banda districts, and in the east to Mirzapur district. The major river, Ganga

Paper 15

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ASSESSING THE MULTI-DIMENSIONAL CONTRIBUTION OF RURAL WOMEN IN FARM AND AGRICULTURAL ACTIVITIES IN THE VILLAGES OF TEHRI GARHWAL DISTRICT: A GEOGRAPHICAL ANALYSIS

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Abstract

Rural women are the backbone of workforce and an essential part of the Indian wealth. In this paper an attempt to analyze the taking part of rural women in farm and agricultural activities and faced various problem and challenged in the villages of Tehri Garhwal district of Uttarakhand.For this study we are selected three villages of Tehri Garhwal district where maximum population of women depends on the agricultural activities namely (Akhori, Melatha, Paukhal villages). Women associated with various activities like Transportation, Snowing, Harvesting, fodder cutting, bee keeping, pottery farming, milking and sheep and goat rearing in the rural area of Uttarakhand. Their source of income and livelihood sustainability directly depends on the primary activities in the study area. Rural women are the internal part of the society and deals with the multifarious responsibilities from child caring to agricultural field preparing. Rural women in the study area are affected by the various factors which are affecting the women health that arises due to the work load and women security in the work place. Due to the work load women indulge in various diseases like headache, vision problem, joint pain, back pain, and body pain. They spend lots of time in the agricultural field for the good production of their crops and other allied sectors.

Key words: - Rural women, Involvement, Multifarious responsibilities, Women security, Livelihood sustainability, Agricultural activities.

1 Introduction

Rural Women considered as the back bone of agricultural and take part in the farm production andprotection. In villages of Uttarakhand women participations mainly seen in agricultural and farm activities. Women associated different type of works in the society. Over the period of time, we can see various changes in agricultural and allied activities. Women are the internal part of our society and doing the dual responsibility in society in the rural area. Rural women in the rural area of Uttarakhand habitually deal with multifarious households and follow various livelihoods policies. They are associated with the producing agriculture production, animals rearing, preparing and processing of food, working for earnings in agricultural or other rural industrial sectors, collectinganimals' dung for fuel and fodder, working in and marketing and small-scale industries, sympathetic for family member and maintained their houses for the survival in the society.

Rural women not only contributed in physical output but also maintained the quality and efficiency in the work force (Ramsan, 2019). Female participation in agriculture and farm activities is decreasing day by day due to poor technology development, Low wages, poor soil texture and lack of agricultural education in rural area (Kumar, 2021)(Acharya et al., 2010)

Paper 16

IMPACT OF SARS-COV2 VIRUS ON WORKERS OF PAURI TOWN, UTTARAKHAND – A GEOGRAPHICAL PERSPECTIVE

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Abstract

Sars-cov2 (Novel-Corona Virus) Pandemic has affected worldwide and influenced all the major countries of the world, Tourism and transportation economic activities have negative trends on graph. This paper analyzes the effect of the Sars-cov2 (Novel-Corona Virus) pandemic on different categories of workers such as Permanent, Semi-permanent, Daily wages (informal sector), Self-employed. Government imposed various restrictions during Pandemic. There are various consequences of the pandemic, workers income is affected during pandemic workers also facing shortage of food supply during pandemic.

Some of Permanent workers helped others during pandemic, some of them contributing their money to the Prime Minister Care fund or Chief Minister care fund during pandemic. Work from home initiative adopted by the various organizations and government, in this Investigation of Pauri, Researcher investigates people's perspective on work from home, is it easy or challenging for them. Worker's workload increases or decreases; are they happy with these initiatives? All of the things are discussed in this paper. How many days daily wages workers opened their shop, is it using sanitizing techniques during work, Shopkeeper getting proper supply of goods from different channels during pandemic or not all these types of things are discussed.

Keywords Sars-cov2, Self-employed workers, Permanent workers, Semi-permanent workers, daily wages workers, Shortage of Food.

Introduction

Sars-cov2 virus pandemic outbreak facing during March month of 2020 in the world, major economies of world facing a dangerous pandemic of the infectious virus of Sars-cov2, and it impacts almost all the countries of world, it impacts mainly socio-economic structures, trade, transportation everything were stopped due to various restrictions by the governments of different countries, the impact of the Novel corona virus pandemic leads to a slowdown in domestic demand and the economic growth of the countries. This will hamper purchasing power of the different working class due to job losses or pay cuts. The slowdown of economies effect of deferred order will have a longer-lasting impact on different sectors of workers, manufacturing sector and service sector have noticed negative, and agriculture sectors have less impact of a pandemic due to self sufficiency of agriculture in India.

India is country with vast geographical extent and huge population also has negative impact of Sars - cov2 virus pandemic, as a today, millions of cases counted and lakhs of people loss there life. Sars-cov2 virus spatially distributed all over the country; it has the largest concentration seen in urban areas of Maharashtra, Delhi, Kerala, Uttar Pradesh, Punjab, and Haryana. Uttarakhand also facing challenges during pandemic, it has counts thousands of cases, urban areas of the Uttarakhand have negative impact; Major cities like Dehradun, Rishikesh, Hardwar

Paper 17

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A Geographical Analysis of Rural Out-Migration And Its Impact on The Rural Landscape of Selected Villages in Garhwal District (Uttarakhand)

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Abstract: Rural out-migration is a common spectacle in hilly areasof Uttarakhand state and is directly associated with the socio-economic conditions of rural people. It plays a major role in the transformation of the rural areas into resonating environments because major populated villages show decline in population growth, agricultural activities, rural development, labour migration and rate of employment. Migration refers to the geographic movement of people from a particular area to another area for various purposes and continues to bethe main problem in the rural areas of Uttarakhand. Unemployment and Lack of basic facilities are the major reasons for out-migration in these areas. In this paper, an attempt has been made to analyze the rural out-migration in Dang, Agrora, Kolri, and Morora villages of Garhwal District. In this study, various dimensions of rural out-migration are considered including the types ofout- migration, purpose of migration, years wise, migration in the age group, inter and intra-state migration. It also analyses the impact of out-migration on the rural landscape through principal component analysis. Results indicate that out-migration harms rural landscape because various attributes are in the declining stage with the out-migration such as agriculture, population growth, working population, and businessin study area.

Keywords: Rural Out-Migration • Rural Transformation • Rural Development • Unemployment • Socio-economic Conditions

Introduction

Migration has become a widespread phenomenon in recent years. In UttarakhandHimalaya, it has become a serious problem of rural transformation and affected the population growth, agriculture transformation, and development activities in various villages. Almora and Pauri Garhwal district of Uttarakhand show a tangible decline inthe growth of population in 2011 as compared to 2001 due to huge out-migration. The hardship of village life, socio-economic conditions of small villages become more noticeable as compared to large villages, thus it pretence as a serious cause of out-migration in Uttarakhand (Mamgain, Rajendra P.; Reddy, 2015).Migration rates have changed drastically over the past few yearsin the various caste groups and the villages with the maximum frequencyamong the rural population living in the hilly villages.Though the well-developed rural villagesin the hilly areas with highest living expectancy and better living standardshave reduced rural migration and provided better job opportunities in the hilly areas, yetthe rate of migration has increased in rural areaswith remoteness(Deshingkar, 2010).Rural migration in the Uttarakhand state is one of the main contributors to urban development and growth, due to inadequate chances of economic development found in the rural area.Male out-migration become the serious problem of Uttarakhand state. This serious problem of male migration in a hilly area leads to the overload of work and burden on women(Yadav et al., 2018). In Uttarakhand, the hilly rural belts have been emptyingin