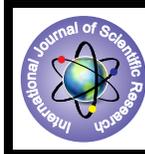


## Advances in Geomorphology Studies: A Perspective on Hydrogeomorphology With Natural Resource Management, Remote Sensing and GIS



### Geography

**KEYWORDS :** Hydrogeomorphology, Natural Resource Management, Remote Sensing and GIS.

Ankana

Research Scholar, Department of Geography, Banaras Hindu University

### ABSTRACT

*Geomorphology as a discipline focuses on the scientific description of evolution of landforms but With the passage of time, the aim and scope of geomorphology have become more and more widen and oriented towards the utility of human being. With the advancement of technologies in remote sensing and GIS, application of hydrogeomorphological studies is utilized in the planning and management of natural resources. Natural resource inventories, delineation of ground water potential zones, environmental management, priority area identified for planning etc., hydrogeomorphology plays an important role. This paper focuses on journey of geomorphological studies with respect to hydrogeomorphology, in terms of natural resource management in association with remote sensing and GIS technology.*

Geomorphology in general is a systematic science to explain the genesis and evolution of a physical landscape. Earlier, geomorphology were concentrated to describe the characteristics, genesis and the processes responsible for the creation of existing landscape, but later on when geomorphology in the early 20<sup>th</sup> century was established as a main branch of geology, then geomorphology started to embrace the other disciplines as well explain the physical phenomenon. Scholars started to recognize the potential of water in the development of landforms. Water undisputedly became the important geomorphic agent in geomorphologic world after milestone work presented by W. M. Davis (1889). Several other works in this field were done by Leopold, *et al.* (1964), Chorley (1969), Dury (1970), Gregory and Walling (1973), etc. The physical processes and drainage basins were explained through mathematical explanations by Horton (1932, 1945) and then developed in detail by Strahler (1950, 1952, 1957, 1958, 1960 and 1964) and his Columbia University Associates, Chorley (1966, 1969), Chorley and Kennedy (1971) etc.

Applied Geomorphology has been developed as a science having its own methods of investigation and principles to study the earth surface features after the formation of a separate Commission on Applied Geomorphology by International Geographical Union (1956) at Rio-de- Janeiro. Geomorphological mapping and survey were considered as an essential pre-requisite tools for applied geomorphological researches. An applied geomorphological mapping system using remote sensing was emphasized at the International Institute for Aerial Survey and Earth Sciences (ITC) in Netherland. Geomorphological survey and mapping were started considering as an instrument in strengthening pure and systematic geomorphological researches and resulting in the form of various thematic maps by Verstappen (1970, 1983, and 1975). Several other scholars also stressed on the importance of these maps [Coz (1972), Tricart (1972), Croft (1974), Rao (1975) etc.].

Geomorphological mapping may be grouped under two themes namely, general mapping and special purpose mapping. Hydrogeomorphological mapping comes under the second theme of mapping. Hydrogeomorphology is a broad scientific domain and relatively a new discipline lie in the sub theme of applied geomorphology that has linkages to the other major fields like hydrology, geomorphology, morphometry, geology, lithology, pedology etc. that's why the term is conceptually so strong that it can provide all physical facets of the region that can facilitate to portray the real image of the area conveniently. Hydrogeomorphology is 'an interdisciplinary science that focuses on the interaction and linkage of hydrologic processes with landforms or earth materials and the interaction of geomorphic processes with surface and subsurface water in temporal and spatial dimensions' (Poole, 2010, Sidle and Onda, 2004). Scheidegger (1973) defined hydrogeomorphology as the study of the landforms caused by the action of water. The integrated study of entire factors em-

braced by this term will surely help to comprehend the present forms and characteristics of the region as well as promises for alleviating developmental problems regarding natural resources by suggesting their possible solutions. The natural resources of any region are essentially the function of interplay between the human knowledge/activity with physical characteristics of that region. Therefore, assessment and management of natural resources could hardly be done without the elementary information about that region and as such hydrogeomorphological aspects play an important role in the decision making for regional resource development. No doubt hydrogeomorphological study gives a promisable help to understand the region that parallelly become inevitable in plans and project implementation, development and management strategies.

Hydrogeomorphological study of the area provides a broad spectrum to comprehend various dimensions regarding the natural resources, their distribution, occurrences, management, etc. The study basically deals with the action of water with the landforms, including surface and sub surface water. Thus hydrogeomorphological maps so generated depict important landforms, prospective zones for ground water occurrences and scope for resource management.

Verstappen (1983) advocates that under special purpose maps, *i.e.*, hydromorphological maps aim to map the characteristics of the terrain features affecting the water resources of the area concerned and the hydrological events, such as peak discharge characteristics, occurring there. These maps take into account of either surface water or ground water resources. In the first case, attention should be given to (i) run off intensities of interfluvies based on the assessment of infiltration, retention and depression storage, (ii) estimated peak discharge of small streams based on catchment characteristics, and (iii) areas with stagnant water or those susceptible to flooding. On the other hand, hydrological maps emphasizing ground water resources should stress (i) assessment of ground water recharge by infiltration, (ii) indication of shallow and deep ground water bodies, and (iii) assessment of base flow characteristics of the rivers. Therefore lithological and relief data and cover types are the main interest in hydro-morphological surveys.

More contributions came in the field of applied geomorphology after the publication of the two books namely *Environmental Geomorphology and Landscape Conservation* by Coates (1973), and *Geomorphology in Environmental Management* by Cooke and Doorncamp (1974). Several works regarding to applied geomorphology were presented by various scholars, namely Thornbury (1954, 1969), Tricart (1972), Coates (1973), Thomas (1974), Hails (1977), Verstappen (1983), Faniran and Jeje (1983), Chorley, *et al.* (1984), Allison (2002), Hugget (2005). In India Chatterjee (1946) and Chhibber (1948) are credited for initiation of geomorphological study and mapping while works of Chatterjee (1946) and

Rao (1975) are considered to present a milestone in the field of applied geomorphology. In this context notable works were done by Dixshit (1970), Sharma (1979, 1986, 1991), Mukopadhyay (1980, 2010), Jha (1983, 2000), V K Sharma (1986), Sharma and Mishra (1993), Mishra, (1993, 1997, 2003, 2006, 2010, 2014), Jog (1995). Geomorphology being a multidisciplinary science has fundamental contribution in the management and planning of the region as well as natural resources development and sustainability. Garland and Humphrey (1980), Young (2000), Muller and Lenton (2009) etc. have emphasized geomorphological knowledge in natural resources inventories. Geomorphological understanding of an area provides primitive base to meet the challenges and issues related to the land occupancy, resource exploitation, environmental management and planning. Various geomorphic techniques and investigations are successfully applied for evaluating resources, socio-economic development and mitigation of natural hazards (Singh and Ojha, 1996). Geomorphological maps can act as a preliminary tool for land management and risk management as well as provide baseline data for other applied sectors of environmental research, such as landscape ecology, forestry or soil sciences (Otto and Smith, 2013, Cook and Doornkamp, 1990).

The resource evaluation and planning aspects of applied geomorphology are concerned with the resource inventories and environmental management, soil and land evaluation (Dent and Young, 1981), production of maps for hydrological, erosional and terrain evaluation (Mitchell, 1973). The three specific roles of geomorphology in environmental management are illustrated as applications to (i) natural hazard avoidance and diminution, (ii) environmental restoration and conservation, and (iii) the sustainable development of natural resources (Gregory and Goudie, 2011). Various studies have witnessed the application of geomorphology in natural resource management and hence environmental sustainability namely, Garland and Humphrey (1980), Knight and Bates (1995) and Mathur (1969), H S Sharma (1980,2003), Singh K. N. (1980), Mishra (1998, 1999, 2006, 2014), Baber (2005), Kalwar, *et al.* (2005), Rawat (2011). These studies suggest that the skills and knowledge through geomorphological

perspective can help in natural resources inventories, mapping, their spatial distribution, and conservation practices. It can very well suggest about tackling problems related to sustainability of a region.

Remote sensing techniques in mapping and analysis of geomorphic features were initially contributed by Vestappen (1970, 1975, 1977 and 1983). Remote sensing (RS) and Geographic Information System (GIS) are now playing a rapidly increasing role in the mapping and analysis of hydrogeomorphological features and natural resources development. Remote sensing techniques are more popularly used in such studies because of its multi-dimensional nature (multi-spectral, multi-temporal, multi-scale and multi-sensors) of data about the earth's surface features. The widespread distribution and extended graphical capabilities of Geographic Information System (GIS) as well as the availability of high resolution remote sensing data such as aerial and satellite imagery and Digital Elevation Models (DEMs) have led to the recent rejuvenation of methods (Otto and Smith, 2013, Lee, 2001, Paron and Claessens, 2011, Smith *et al.*, 2011). One of the greatest advantages of using remote sensing data for hydrological investigations and monitoring is its ability to generate information on spatial and temporal domain, which is very crucial for successful analysis, prediction and validation of hydrological facts (Rajagopal and Arunachalam, 2014). The studies related to geomorphological mapping, terrain analysis and resource inventory using remote sensing may be marked in the works of Way (1978), Vaidyanadhan and Raghavaswamy (1980), Barret and Curtis (1982), Curran (1985), Sabins (1987), Roy (1991), McClay (1995), Campbell (1997), Burrough and McDonnell (1998), Lee (2001), Jenson (2004), Lillesand *et al.* (2008), Dykes (2009), Knight *et al.* (2011), Lo and Yeung (2012). In India, the books authored by Nag (2000), Nag and Kudrat (1998), Gautam and Raghavaswamy (2004, 2005), Reddy (2006), Bhatta (2012) etc. may also help to get knowledge of RS and GIS techniques.

Reliable information on geomorphological units of the area with respect to their nature, extent, spatial distribution, potential, limitations is very useful for evaluation and optimal utilization of natural resources on a sustained basis. The geomorphological mapping of a terrain is a pre-requisite for the soil resources mapping, ground water potential zone identification, landscape ecological planning, hazard mapping and other environmental applications (Pandey, 2005). Scheidegger (1973), Onda and Siddle (2004) and Kar (1993), Murthy and Rao (1999), Kalwar, *et al.* (2005), Baber (2005), Simon (2010) have significantly contributed in the field of geomorphological knowledge and its practical application as well in resource management and environmental sustainability.

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