MULTISTAGE DATA EVALUATION FOR GEOMORPHOLOGICAL MAPPING IN PART OF DOON VALLEY (UP) - INDIA

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ABSTRACT:

Panchromatic black and white aerial photographs on 1:50,000 (approx.) scale in the form of false colour composites on 1:1M (film diapositives) and 1:250,000 (print form) scale were used to evaluate their utility for geomorphological mapping in part of Doon Valley. Using photo elements like tone, texture, pattern and shape, five geomorphic units viz; denudational hills, structural hills, residual hills, piedmont plain and river terraces were delineated and several structures e.g. folds, faults etc., are marked. Aerial photo interpretation gives more classes because of 3-D view and higher resolution. River terraces which are very distinct in aerial photographs cannot be identified in satellite data. The structures like small folds and lineaments are easy to mark. Visual interpretation of satellite data helps in identification of structural hills, active flood plain, abandoned channels and extent of agricultural landuse. The contact between Siwalik belt and Piedmont zone are easy to pick up. Digital image processing enhances the interpretation of major geological structures and lineaments.

KEYWORDS: Classification, Image Analysis, Image interpretation, Remote Sensing Application, Space Imagery.

1. INTRODUCTION

The advent of remote sensing techniques has ushered in a revolutionary change in the methods of studying, surveying and monitoring of natural resources. The multidate remotely sensed data have the inherent properties of providing sequential and synoptic coverage with wealth of various information in less time, cost and efforts. Geological study in Doon Valley has been carried out by various workers using aerial photographs. Rupke (1974) has delineated Damta, Chandpur, Middle Siwalik, Upper Siwalik formations and younger alluvium. Shakdhar D.P. (1984) applied remote sensing to hydromorphogeological studies in parts of Western Doon Valley and revealed that the groundwater conditions have close relation with geomorphology. Chandel, R. S. and Asthana,D. (1990) attempted the evaluation of Remote Sensing Technique for geological studies in eastern part of Doon Valley.

2. STUDY AREA

In the present study about 1600 sq.kms of area on the western part of Doon Valley (Uttar Pradesh) India, is selected to analyze and compare different landforms using multistage remotely sensed data for geomorphological mapping and groundwater potential. The geographic coordinates for the study area are latitude N $30^0 15'$ - $30^0 35'$ and longitude E $77^0 30'$ - $78^0 05'$ (Fig.1). Pretertiary (2200 mts.a.m.s.l.) forming high and steep ridges and Siwaliks (918 mts.a.m.s.l) mark the northern and southern limits of the study area respectively. Intermontane valley fills/intermontane piedmont plain and small patches of residual hillocks lie in between. The main rock types are quartzite, phyllite, conglomerate, sandstone, shale and alluvium (Table 1). Doon Valley is traversed by two antecedent rivers namely Yamuna and Ganga along with their tributaries viz. Giri, Asan, Tons and Song river. They are separated by water divide, formed by the ridge, near Dehradun. Major streams draining Siwalik hills are consequent and are flooded during monsoon. Other seasonal streams have a sizeable discharge during and after monsoon. The drainage pattern existing in different geomorphic units is tabulated in table 2. Occasional rains are experienced during winters, while it is southwestern monsoon during rainy season which nourishes luxurious vegetation.

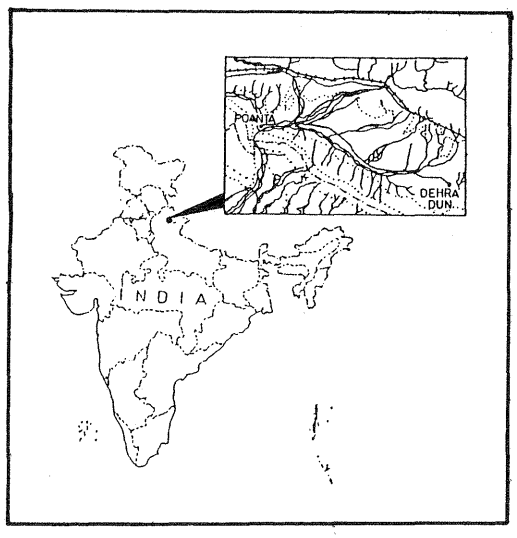

Fig. 1: Location map

Table 1: Stratigraphic succession of the study area

Age	Geological Unit	Lithology	Geomorphic unit
Recent	River Alluvium	Sand, Silt and clay	River terraces
Pliestocene	Doon Fan Gravels	Boulders, Pebbles, sand,	Piedmont zone
	Older Doon Gravels	silt and clay	Residual hills
Middle Miocene	Upper Siwalik	Conglomerate & boulders	Structural hills
To	Middle Siwalik	Sandstone and Clay	Structural hills
Lower Pliestocene	Lower Siwalik	Sandstone and clay	Structural hills
		Main Boundary Fault	
Eocene	Subathu-Dagshai	Shale, Limestone and Sandstone	Denudational hills
		Krol Thrust	
Precambrian to Triassic	Pretertiary	Quartzite, Phyllite, Limestone, Shale	Denudational hills

3. METHODOLOGY

A Geomorphological map of the study area is prepared through visual interpretation of Landsat MSS and TM multidate data in the form of false colour composites (FCC) with limited field checks. About 74 panchromatic aerial photographs on 1:50,000 (approx.) scale have been interpreted stereoscopically. Based on image characteristics like tone, texture, shape etc., and geomorphic elements like drainage (Fig. 2) and landforms, broad geomorphological details of the area have been demarcated. Imavision computer system was used for acquiring digitally enhanced output of the study area.

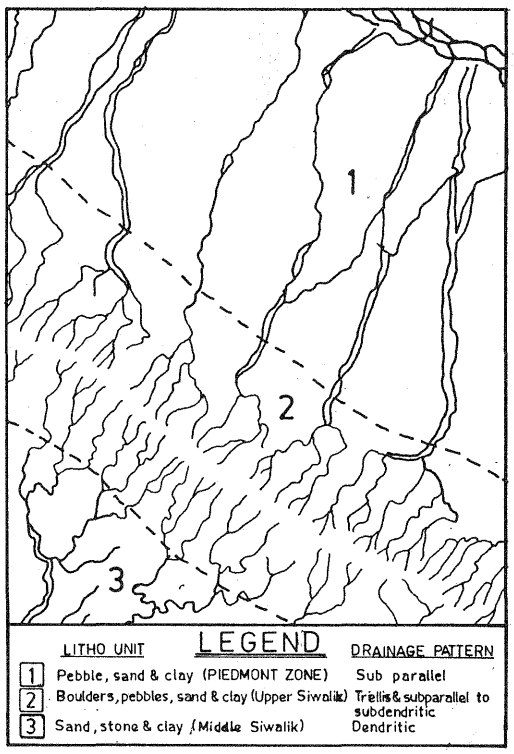

Fig : 2 Lithological Impact on Drainage pattern

4. RESULTS AND DISCUSSION

4.1 Aerial photo interpretation

The photogeomorphological map of the study area is shown in Fig. 3. Details of gemorphological features like braided river channel, flood plain, point bars, channel bars are deciphered clearly. River terraces both depositional and erosional ones are present. Composed of unconsolidated river borne sediments, these terraces indicate former level of valley floor/flood plain and reflect variation in base level of the river. The respective terrace levels identified along the Yamuna, Giri and Asan rivers are seven, five and one.

The intermontane valley is filled with river borne sediments. Source material for this unit is Pretertiary (North) and Siwalik group of rocks(South). Small residual hillocks are present in NE of Paonta, Near Dakpathar, Langha, Dongha and north of Dehradun. The hillocks of Old Doon Gravel (ODG) are composed of big boulders, pebbles of quartzite, cherts and sandstone; sand and clay. Structural hills in Siwalik formations display various faults, folds, gently and steeply dipping strata. Landforms like Hogbacks and cuesta are seen distinctly in these hills.

The major geological formations like River alluvium, Doon Fan Gravels (DFG),

Table 2: Hydromorphic Zonation of Study Area

Geomorphic unit	Drainage	Hydromorphic Zone
Flood plain	-	Recharge zone
River terraces	-	Recharge zone
Piedmont zone	Sub parallel and anatomosing	Enrichment zone
Residual hills	Dendritic to Sub dendritic	Discharge zone
Structural hills	Dendritic, Sub parallel to trellis	Discharge zone
Denudational hills	Dendritic to Sub dendritic, trellis	Discharge zone

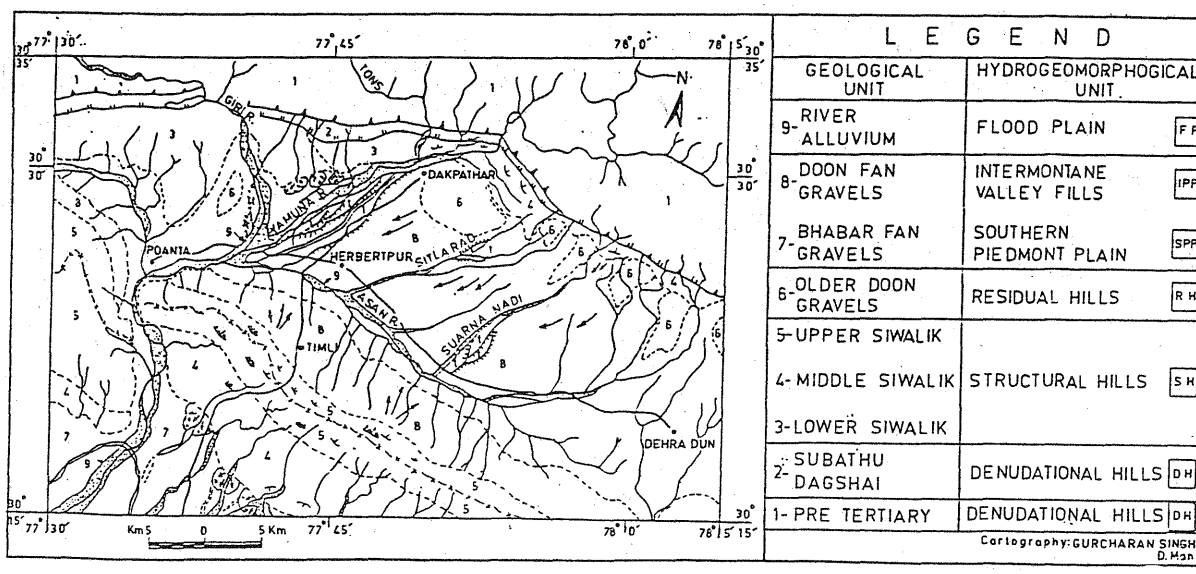

Fig. 3: Photogeomorphological Map of the Study Area

Old Fan Gravels, Upper Middle and Lower Siwalik group of rocks, Subathu-Dagshai formations and Pretertiaries are demarcated on the basis of tone, topography, drainage and land use. The photo characters of different units present in the study area are tabulated in Table 3.

Doon valley is an asymmeterical synclinal valley trending in NW-SE direction. The major structures present in the study area are Main Boundary Fault (MBF), a reverse-fault and Krol Thrust, a low angle thrust. MBF runs almost parallel to Krol Thrust upto Pipalsar and then merges with Krol Thrust in the eastern part.

In aerial photointerpretation Krol Thrust is identified by its linearity towards NW-SE and Knick points. Fractures, joints and other lineaments are found in plenty trending mainly in two major directions viz., NE-SW and NW-SE. Numerous springs occur due to fractures in Krol limestones.

The groundwater conditions of the area are mainly controlled by structures, lithology, relief, climate and vegetation. The hydromorphic zonation is attempted to demarcate the study area into groundwater recharge zone, enrichment zone and discharge zone (Table 2). Reduced water level contour map indicates the groundwater flow towards Asan river from Piedmont plain and then towards west along synclinal axis of asymmetrical Doon Valley. DFG and underlying old terrace deposits constitute the main aquifer. Thus, intermontane valley fills have better groundwater potential. Depth to ground water is deep. Its depth would depend upon the thickness of the fan materials or to the depth of the underlying impervious Upper Siwalik beds. Depth to water level varies from 2 metres to 97 metres. Discharge of tubewells ranges from 260 litres/minute(lpm) to 4292 lpm.

Table 3: Photo Characters of Different Units

Geological unit	Geomorphic unit	Tone	Topographical Expression
River Alluvium	Flood Plain	Light	-
	River Terraces	Light	-
Doon Fan Gravels	Piedmont zone	Light to Medium	Gently sloping
Old Doon Gravels	Residual Hills	Medium to Dark	Moderately sloping
Upper Siwalik	Structural Hills	Light to Medium	Subdued Topography
Middle Siwalik	Structural hills	Dark	Moderately to steeply sloping
Lower Siwalik	Structural hills	Dark	Moderately to steeply sloping
Subathu Dagshai	Denudational hills	Medium to dark	Moderate to High High relief
Pretertiary	Denudational hills	Dark	High Relief

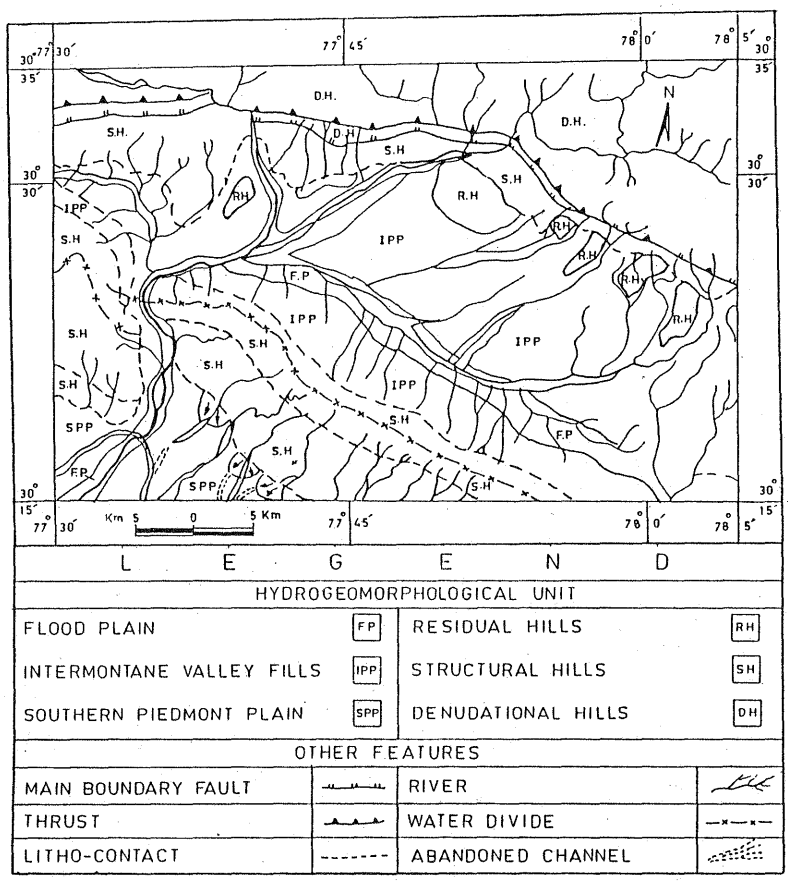

Fig. 4: Geomorphological map of study area based on visual interpretation of Landsat TM.

Table 4: Comparative Study of Multistage Remote Sensing Data

Name of feature	Identification criteria	Aerial photo-	Landsat	Digital analysis
Geomorphic features				
Flood Plain	Tone and Association Landuse	Very Clear	Clear	Clear
River Terraces	Association and Landuse	Very Clear	Absent	Absent
Piedmont Zone	Drainage and landuse	Clear	Clear	Clear
residual hills	Tone, Topography, Drainage	Clear	Very Clear	Clear
Structural hills	Tone, Topography, Drainage	Clear	Very Clear	Clear
Denudational hills	Tone, Association Draiange	Clear	Very Clear	Clear
Lineaments	Shape/Linearity	Fair	Clear	Very Clear
Palaeo channels	Tone	Clear	Very Clear	Clear
Water bodies	Shape and tone	Clear	Very Clear	Very Clear
Fans	Shape and association	Very Clear	Clear	Clear
Litho contacts	Drainage	Fair	Very Clear	Clear
River channel	Braided Nature	Very Clear	Clear	Clear
Geological Features				
Alluvium	Whitish tonal contrast	Very Clear	Clear	Clear
Doon Fan Gravels	Drainage	Clear	Very Clear	Clear
Old Doon Gravels	Drainage/Topography	Clear	Very Clear	Clear
Upper Siwalik	Drainage topography	Clear	Very Clear	Clear
Middle Siwalik	Drainage	Clear	Very Clear	Clear
Lower Siwalik	Drainage	Clear	Very Clear	Clear
Subthu-Dagshai	Drainage	Clear	Very Clear	Clear
Pretertiary	Drainage topography	Clear	Very Clear	Clear

4.2 VISUAL INTERPRETATION OF SATELLITE DATA

Based on different photo characters, drainage dissection pattern and vegetation cover, broad geomorphological discrimination has been made (Fig.4). The abandoned channels are descernible on the basis of tonal variation and pattern. Light tone clearly demarcates the active flood plain of major rivers. Other land forms like sand bars, channel island and braided streams are easily discernible. River terraces, very distinct in aerial photographs, could not be identified in satellite image. Denudational hills are identified on the basis of coarse drainage, dendritic to subdendritic pattern, high relief and rugged topography. Highly dissected structural hills with rugged topography are identified in FCC by deep red colour due to vegetation.

Geological discrimination of study area with visual interpretation of satellite data is easy. Contact between Siwalik belt and piedmont zone is easy to pick up. Middle and Upper Siwalik contact, though gradational, can be demarcated due to change in drainage pattern and tonal variations. Main Boundary Fault, Krol thrust and other lineaments are more easy to demarcate in satellite image due to their linearity.

4.3 DIGITAL ANALYSIS

The main objective of digital analysis is to enhance the image and to extract maximum information that may be difficult to decipher on the imagery and aerial photographs (Table 4). For this study, the entire Landsat 5 TM, CCT (Quadrant II, tape 2 dated 3.3.87) was displayed on the display unit of IMAVISION system. A sub area of 512 x 512 (scan x pixel) was selected for detailed study. Following enhancement techniques were performed on the system and the output product was obtained using a 35 mm camera for comparison.

4.3.1. Principal component (PC) 1,2,3
4.3.2. Band 5/4, and 3/1, Band 5/7 Ratio
4.3.3. Band 3/1 ratio
4.3.4. Band 5/7, Band 5 and Band 7

Techniques 4.3.1 and 4.3.4 are good for lineament studies, delineation of residual hills, piedmont zone and water bodies. Technique 4.3.2 shows clear water bodies and different types of vegetation. Lineaments and residual hills are easily descernible through technique 4.3.3. Technique 4.3.4 gives very good results in separation of water bodies, residual hills and piedmont zone. Lineaments are quite prominent from river channels. Drainage pattern is clear. Dry channels and channels with water can be clearly separated. Differentiation of vegetation on the basis of tone is also possible through this technique.

5. CONCLUSIONS

In area like Doon Valley, scanning of air borne data and visual as well as digital interpretation of space borne data exhibit their immense potential for detailed study, demarcation of different geomorphic, geologic units and lineaments analysis. Aerial photographs have provided more details. The structures like minor folds with dip and strike, were easily marked. River terraces could be identified only with aerial photographs. Visual interpretation of satellite data is more useful for regional studies because of synoptic coverage. It was good for geological and structural studies. Digital analysis was found to be more useful for geological discrimination and lineament studies.

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