THE BRAHMANI BASIN

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1. **OBJECTIVE**

The main objective of the present study is to apply morphometric techniques in the geomorphic analysis of the Brahmani Basin and deduce, therefrom, the suitability and significance of the techniques as well as the geomorphic evolution of the Brahmani Basin as a whole.

As we know the term 'morphometry' is used in several disciplines to 'mean the measurement and analysis of form characteristics. In geomorphology it is applied to numerical examination of landforms' (Gardiner, 1982, p. 107). In this discipline, therefore, it is defined as 'the measurement and mathematical analysis of the configuration of earth's
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surface and of the shape and dimensions of its landforms' (Clarke, 1966, p. 235). The main aspects thus examined are the area, altitude, volume, slope, profile and texture of the land as well as the varied characteristics of rivers and drainage basins. During the present century, particularly after 1940s, morphometry has been used primarily to facilitate description of specific relief features — erosion-surfaces, slopes, valleys and that of the character of relief as a whole. It has also been used as direct or indirect evidence for the genesis and evolution of certain landforms. More recently, morphometry is concerned mainly with intensive analysis of small morphological units — notably drainage basins (Clarke, 1966, p. 236).

It is so because the application of morphometry in geomorphic analysis of a drainage basin provides a sound footing to this discipline. By analysing various properties of a drainage basin, the degree of internal adjustment which has taken place among different properties and stages of basin development can be established. Morphometric analysis of the Brahmani Basin is, therefore, an attempt to measure the degree to which the present set of processes has externally or internally adjusted to variables of the Basin in relation to each other. It will, moreover, lead to the precision and concrete
conclusions relating to the geomorphic evolution of the Brahmani Basin.

1.2. STUDY AREA

The study area, the Brahmani Basin, lies between latitudes 24° 12' 45" N. and 24° 29' 30" N. and longitudes 87° 18' 00" E. and 88° 01' 00" E., covering an area of 1323.50 square kilometres in the States of Bihar and West Bengal. It has two distinct segments. The western part of the Basin is included in geomorphic provinces of the north-eastern continuation of the Chotanagpur plateau. This is a part of the administrative district of Old Santhal Pargana and presently of fragmented districts of Dumka, Godda and Sahebganj in Bihar (Fig.1.1). The eastern segment of the Basin is a portion of the Ganga plain including the administrative districts of Birbhum and Murshidabad of West Bengal. The Basin occupies 75.52 and 24.48 per cent area in Bihar and West Bengal respectively.

The Brahmani Basin has a diversity of relief and forms consisting of plains, plateaus and hills. The river Brahmani rises from the Rajmahal highlands near Karbinda Bazar at about 207 metres above mean sea level. It flows through Pharasemul and Sankara and forms the southern boundary of
FIG. 1.1
**STUDY AREA**

Damin-I-Koh. It leaves the Dumka district (Bihar) at Darin Mauleshwer and enters into the Birbhum district (West Bengal) to join the Dwarka after crossing the Eastern Railway at Nalhati Station. The Brahmani Basin is exorheic, where all surface drainage goes to the Dwarka and ultimately to the Bhagirathi, a distributary of the Ganga and then to the Bay of Bengal. The Basin is delimited by Pagla and Bansoly on the north, Dwarka on the south, Mayurakshi on the west and Bhagirathi on the east (Fig. 1.1).

The Brahmani Basin is a well-defined geomorphological unit. It comprises of two conspicuous geomorphic units — the hilly tracts in the west covering almost three-fourth of the Basin and the Gangetic alluvial plains in the east covering rest of the area. The principal range in the west is that of the Rajmahal hills. The hills stretch from north-west to south-east up to the Brahmani river. In the south of the Brahmani river, there is a small range of hills known as the Ramgarh hills. These hills are the extension of the Rajmahal range, but they are not so high and they have a more rounded and undulating outline. Thus, the western portion consists of a succession of hills, plateaus, valleys and ravines, general elevation of which varies from 150 metres to 250 metres, though some hills have an altitude of 450 metres and above.
The loftier peak of the Rajmahal hills is situated on the north-west of the Basin called Mahuagarhi (503 metres). The eastern narrow part of the Basin is entirely flat, lying on the lower Gangetic plain. The alluvial plains are monotonous with wide and flat river valleys.

The western ancient landmass includes a variety of landscape units. Unhindered erosion has exposed the granitic-gneissic cores, easily seen along the valley of Gumra Nala and Brahmani (Plate 1.1), while uplifts, tilting and warping have caused rejuvenation initiating new cycle of erosion. Being a part of the Peninsular India, it suffered from Carboniferous crustal movements which manifested themselves into block type of earth movements developing tensional cracks and subsidence forming Gondwana basins (Hunday & Banerjee, 1967, pp. 17-22). The outpouring of the Rajmahal lava during the upper Gondwana periods is remarkable episode in the geomorphology of the area. During the end of the Mesozoic Era and the commencement of the Tertiary Era, a conspicuous revolution of the land and sea was initiated and culminated in the uplift of the Himalayan orogeny and separation of the Indian Peninsula from the Indo-African continent. These are responsible for the uplift and tilting of the Chotanagpur area. Rajmahal has formed a hinge zone, tilting to the north and
east developing the western and south-western scarps of the Rajmahal highlands. These events -- lava flows, uplift, tilting and erosion are related with the Indian Peninsula in general and Chotanagpur in particular, and they have their imprints upon the geomorphology and drainage network of the study area (Chakrabarti, 1985, p. 2).

Between the Gangetic plain to the east and Chotanagpur plateau to the west there is a belt of country sloping eastwards. This may be called as the plateau fringe area which has come into existence at the expense of the Chotanagpur plateau. This area testifies prolonged erosional processes as controlled by the base level of erosion (Chakrabarti, 1985, p. 3). It comprises of laterite formation. 'In fact, all along the eastern margin of the Deccan shield we can see laterite terraces' (Chakraborty, 1970, p. 20). This laterite tract was the first deltaic landform developed in the Miogeosyncline of the Naga-Lasai orogen (Chakraborty, 1970, p. 20).

The eastern part of the Basin comprises a part of the Gangetic plain. Approximately to the east of 87°E. longitude the Archaean basement complex disappears below the Gangetic alluvium (Sengupta, 1970, p. 1). Geophysical evidences show that the Bengal plain or Bengal delta is a thick overlay of sediments of the Garo-Rajmahal gap which separated the
Archaean surface of the Assam hills from the Deccan shield. This Garo-Rajmahal gap surely formed a landmass for a long time (Chakraborty, 1970, pp. 16-29). There is, however, no geosynclinal evidence to help us to ascertain the exact date up to which the Garo-Rajmahal shaddle remained a part of the ancient landsurface of Bengal (Sengupta, 1970, p. 1).

All these contrasts in topography, drainage, gradient as well as basement rocks present an interesting details for geomorphic study of the area. It is on this merit that the area, the Brahmani Basin, has been selected for such a study.

1.3. PREVIOUS STUDY

The Brahmani Basin, stretching both in the Chotanagpur plateau and Gangetic plain has attracted the attention of eminent geologists and experts of various disciplines. The mineral wealth of Chotanagpur has attracted the geologists (Dunn, 1942) and the possibility of the existence of petroleum caused a detailed study of the Gangetic alluvium of the Bengal basin (Sengupta, 1970, pp. 1-6).

But no separate study exclusively on the geomorphology of the Brahmani Basin was done previously. Geologists while treating geology of the Rajmahal highland have studied rocks and topography, phases of denudation, deposition,
earth-movement and even effusion. Each of these has formed
the primary base for redrawing the morphological architec-
ture. The author, therefore, records some of the existing
geological and geomorphological work covering the area.

Colebrook (1801), Wilford (1805), Jones (1829) and
Buchanan (1831) have furnished information regarding the geo-
logy and mineral wealth of the Rajmahal highlands. Geological
Survey of India took the investigation of the area in the
second quarter of the 19th century, when Oldham (1859) in a
number of papers reported the geology of the Rajmahal hills.
In the record of G.S.I. Feistmantel (1876) has given a preli-
minary account of the conclusions regarding the age of rocks
of the Rajmahal series. Walter (1951) has given an interest-
ing account of the people and geology of Damin-I-Koh.

But the first detailed study of the Rajmahal was
undertaken by Ball (1877) whose reports and discussions pro-
vide starting point of geomorphology of the area. Ball was
the first to map the geological formation of the Rajmahal on
a scale of one inch to four miles. His study of the geology
of the Rajmahal hills has given us a detailed idea of the
rock formation, structure and geological history of the
Rajmahal hills. The Geological Survey of India is making
further study of its economic geology and other branches.
Pascoe (1963, 1973, 1975) has presented a systematic account of its geology, although the studies by Wadia (1966) and Krishnan (1968) have outlined the structure in a concised manner. But all these studies are mainly on the geological aspects and they have worked as geologists rather than geomorphologists.

In recent years there is some advancement in the study of the geomorphology of the Chotanagpur area. The first credit goes to Chatterji (1945) for his work on the Ranchi plateau. He has also discussed the evolution of the physiography of the Chotanagpur in general (Chatterji, 1949). A detailed study on the geomorphological evolution of the Chotanagpur has been attempted by Singh (1969). His work is a pioneer in the field of geomorphology. In addition to Chotanagpur he made a detailed analysis of the geomorphology of the Rajmahal highland - its structure, tectonics and erosional history and above all the evolution of the drainage pattern. Ahmad (1958) has quoted Dunn to describe tilt of the Rajmahal in geomorphic outline of Chotanagpur. Recently a short treatise of field investigation of the area appeared in a paper by Bandyopadhyay (1972).

The study of the geomorphology of the Bengal basin, on the other hand, has been carried out by another group of
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Geologists, which has opened the field of study of the area concealed below the Holocene alluvium. Sengupta (1970) assessed the evolution of this part of Bengal with the help of borehole data. Later Sengupta (1972) has analysed the geomorphology of the Bhagirathi-Hooghly river basin. Chakrabarty (1970) has dealt with some problems of the evolution of the Bengal delta. Hunday and Banerjee (1967) has traced the geomorphological evolution of this part of Eastern India.

Besides, many authors have analysed the geomorphology of the Chotanagpur plateau which is of great value to ascertain the geomorphic evolution of the Brahmani Basin. The work of Satyakam (1956), Kumar (1968) and Mukhopadhyay (1980) are notable. The Ph.D. theses of Singh (1976) and Chakrabarti (1985), D.Litt. thesis of Prasad (1979) and a number of research papers have been helpful for the proposed study.

Last, but not least, the supervisor's suggestions and information are actually the fundamental source to the author.

1.4. Methods

Geomorphology is, in fact, the science of landforms, but it is difficult to make a scientific analysis of the geomorphology of a country without carrying intensive field study. 'Field studies play a vital part in nearly all geomorphological
investigations' (King, 1966, p. 31). Observations in the field are essential either to formulate or to test hypothesis and theoretical calculations, and they must also accompany model work. Thus, geomorphology is essentially a field study, but it is also an accepted fact that all the problems in the field cannot be solved mainly because of the great complexity of geomorphological processes in nature. The present work tries to unravel the geomorphic evolution of the Brahmani Basin with the help of a number of morphometric techniques based on laboratory and field studies.

The landforms of any part of the earth surface are not only the result of any particular process, rather they are a function of interaction of different processes. There is a growing tendency in the field of geography to correlate the field of action and interaction of a set of processes which are subject to particular functions. But it is rather impossible to fulfil such a type of objective, specially when there is a lack of readily available data related to the subject matters of the study. That is why the object of this study is confined to issues noted below:
(a) Proper assessment of the geographical background of the Brahmani Basin with special reference to its geomorphology,
(b) Analysis of a set of morphometric attitudes and variables,
(c) Application of morphometric attributes to the geomorphic
(d) Derivation at some concluding corollary mainly from the aforesaid analysis with supplementation of the field work.

At the initial stage of the present work, 1 : 50,000 (2 cm. = 1 km.) topographical maps (72 P/7, 8, 11, 12, 15, 16, and 72 D/4) published by the Survey of India have been taken as basic tools. Compiling all these topo-sheets three base maps of the Brahmani Basin showing contour, drainage and communication lines were prepared (Figs. 1.2, 1.3 & 1.4). Then the area was divided into 1436 matrices (Fig. 1.5), each having an area of one square kilometre. Many copies of outline map having grids of one square kilometre, but in reduced form (1 cm. = 1 km.) were done for the convenience of work and to get the maps handy.

The next stage was associated with the derivation of values from the topographical maps for each grid for morphometric analysis and mapping. The basic data of different attributes of landforms such as Relative Relief, Absolute Relief, Average Relief, Dissection Index, Roughness Index, Ruggedness Index, Average Slope, Drainage Density, Stream Frequency, Drainage Texture, Constant of Channel Maintenance, Source Heads and Confluence Points were obtained for each grid.
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CONTOUR INTERVAL 20 METRES

ABOVE 200 METRES

Source: 1:50000 Topo-sheets
COMMUNICATION LINES

- RAILWAYS
- METALLED ROAD
- STATE BOUNDARY
- DAMIN-I-KOH BOUNDARY
- UNMETALLED ROAD
- CART-TRACK
- PACK-TRACK

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Source: 1:500000 Topo-Sheets
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It should be mentioned that topographical sheets do not always give specific information about geology, vegetations, climate, soil and other important aspects, essential for geomorphological study. The geology of the Basin has been studied in detail by critical appraisal of all the published works, i.e., records, memoirs, monographs, journals and books of the G.S.I. as well as by consultation of both the published and unpublished geological maps. The study of climate is necessary to an understanding of geomorphic processes. As the area does not have any meteorological centre, the climatic data depicting temperature and rainfall of Naya Dumka in the west and Berhampur in the east have been collected from the records of Indian Meteorological Department, Alipure. From the analysis of five yearly moving average of rainfall, simple monthly average of rainfall and temperature, spatial distribution of average rainfall, temperature range etc., we get an idea of the impact of climate on the present day distribution of geomorphological processes in different terrains of varying lithology and structure. The study of soil type and natural vegetation is done on the basis of the data available from the Department of Agriculture, West Bengal, the Rajendra Krishi Mahavidyalaya, Bhagalpur and the Forest Office of Birbhum.

The main aspect, the morphometry, covers the analysis
of drainage (linear and areal aspects), relief (relative relief, absolute relief, average relief, dissection index, ruggedness index, roughness index, area - height and altimetric analysis), slope (total surface slope distribution by Wentworth and Raisz & Henry method; channel gradient including serial profiles, superimposed, projected and composite profiles, cross valley profiles, long profiles, computed long profile, i.e., \( Y_c = ab^X + K \) and hill side slope, etc.) and sample drainage basins. Contour maps tell much more the story of relief, the differences in height above sea-level. "To the trained eye of a geographer and geologist they also tell the story of the way in which the relief was developed" (Putnam, 1962, p. 407). But for the author it required some laboratory work. So, various methods stated above follow the book of Monkhouse (1970) although the books of Lobeck (1939), King (1966), King and Doornkamp (1971) and Dury (1970) and many others have been consulted. The author has drawn maps, diagrams, profiles etc. to make the interpretation of the geomorphic features easy and comprehensible.

'Like many other branches, geomorphology is becoming more quantitative in its method and statistical techniques play their part in many stages of study' (King, 1966, Preface). So, statistical analysis of morphometric variables plays a very significant role in the analysis of the Brahmani Basin.
For the statistical analysis the books of Doornkamp & King (1971), Pal (1982), King (1969) have been consulted. The Brahmani Basin has been studied at macro and micro levels.

In macro basin approach of the Brahmani Basin, the statistical analysis includes geomorphic relation of number, length and area to order, coefficient of correlation (r) by Pearsonian product moment method, coefficient of determination ($R^2$) and fitting the regression lines to different drainage network variables. Again the coefficient of correlation (r) by a two-way frequency table, coefficient of determination ($R^2$) and regression coefficient are calculated between:

(a) Average relief and other morphometric variables.
(b) Relative relief and other morphometric variables.
(c) Dissection index and other morphometric variables.
(d) Average slope and other morphometric variables.
(e) Roughness index and other morphometric variables.
(f) Drainage density and others.
(g) Stream frequency and others.

There is high degree of correlation between some of the variables such as relative relief vs average slope, relative relief vs roughness index, average slope vs roughness index, drainage density vs stream frequency. The superimposed
regression lines have been drawn from regression equations.

At micro level ten (10) selected sample basins of same order (4th order) were chosen for statistical analysis to see whether they actually reflect the same nature of morphometric properties on the major Basin Brahmani. Simple and multiple relationships have been made between different geomorphic variables. The correlation matrixes of different geomorphic variables have been studied at 1% and 5% significant level.

Lastly, the study is supplemented by field work undertaken by the author on different parts of the Basin, while the some parts of the Basin is inaccessible for its rugged topography and dense forest. Fortunately the author travelled by motor cycle and made halting at various places like Kathikund, Gopikander (Plate 9.3) etc. around which the characteristic area could be observed. And then much of the work was finally done on foot. The data for hill slope profiles have been taken by Abney level during the field study (Plate 9.1).

The work is also supplemented by photographs illustrating specific landscapes or important details. It is often said that 'any fool can use a camera but it is a particular foolish geographer who neglects to take plenty of illustrative photographs' (Putnam, 1962, p. 403). So the fellow
photographer (Plate 5.2) took as many pictures as directed by the author, either it was the common and more or less monotonous features of the area under study or the most striking feature as a whole; for he might not visit the place again. It has become easy for the author to discard unrequired photographs, while an opportunity not utilised to the full might result in lasting regret.

However, it may be said that most of the methods applied to the region, are simple, less complicated. Many methods, the author feels, are based upon complex equipment which is beyond the scope of many geomorphologists in India; and as such those methods could not be adopted to the study of the Brahmani Basin.

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