SUMMARY

The study of a 665 sq km area located in the western part of West Bengal has been completed through both aircraft and satellite imageries mainly for the purpose of recording basin characteristics of the Taraphini river basin from a flood mitigation point of view as well as to assess the efficacy of various remote sensing techniques and outputs in this context.

This Precambrian terrain exhibits a complicated structural configuration, and a detailed geological-cum-structural map has been prepared from aircraft imageries supported by extensive field investigation. Similarly, a detailed geomorphological map and a land use map have been prepared from black-and-white and colour infrared aircraft imageries.

From the above outputs, a detailed land cover map has been generated, which forms the basis for the estimation of the river flow for various rainfall intensities. There is a close correlation between estimated river flow data and actual river flow data observed at a rain gauge station; utility of remote sensing information from the view point of flood studies is thus demonstrated.

Further, through visual and digital processing of various remote sensing imageries taken from aircraft and satellite and comparison with Survey of India topographic sheet and with limited ground information in a 32.5 sq km test site near Lalgarh, an optimum modality has been devised for extracting maximum information by suitable integration of Landsat imagery, aircraft imagery and ground information.

CHAPTER - I

INTRODUCTION

C H A P T E R I

LOCATION AND ACCESSIBILITY

The area under study covers approximately 665 sq km falling in Medinipur, Bankura and also partly in the Puruliya Districts of West Bengal and in Singhbhum District of Bihar (Fig.1.1) and lies between 22° 32'N and 22° 47'N latitudes and 86° 36'E and 87° 04'E longitudes. The area comprising the Taraphini River Basin is located in the Survey of India topographic sheet numbers 73 J/9, 10 and 14 and 73 N/2. The R. Taraphini is one of the important tributaries of R. Kangsabati (Kasai) in its upper reaches. The total catchment area of the Taraphini is about 331 sq km. The Taraphini originates in the northwestern hills of the Jhargram subdivision of the Medinipur District.

The area is accessible by a motorable road to the subdivisional town Jhargram which is located 155 km west of Calcutta and situated in the Howrah-Nagpur trunk route of the South Eastern Railway (Fig.1.2). Big villages in the area are Binpur, Silda and Belpahari which are connected to Jhargram by motorable roads. Some parts of the area are easily accessible through a network of jeepable roads while some portions of the area are accessible only by cart tracks and foot tracks.

PURPOSE AND SCOPE OF WORK

Recent developments in space technology have greatly enhanced the capabilities of resources survey and mapping. Remote sensing techniques provide direct assessment of land characteristics, vegetation cover and the hydrologic processes operating in a particular area.

MAP OF THE STUDY AREA AND ITS SURROUNDINGS
SHOWING DISTRICT BOUNDARIES

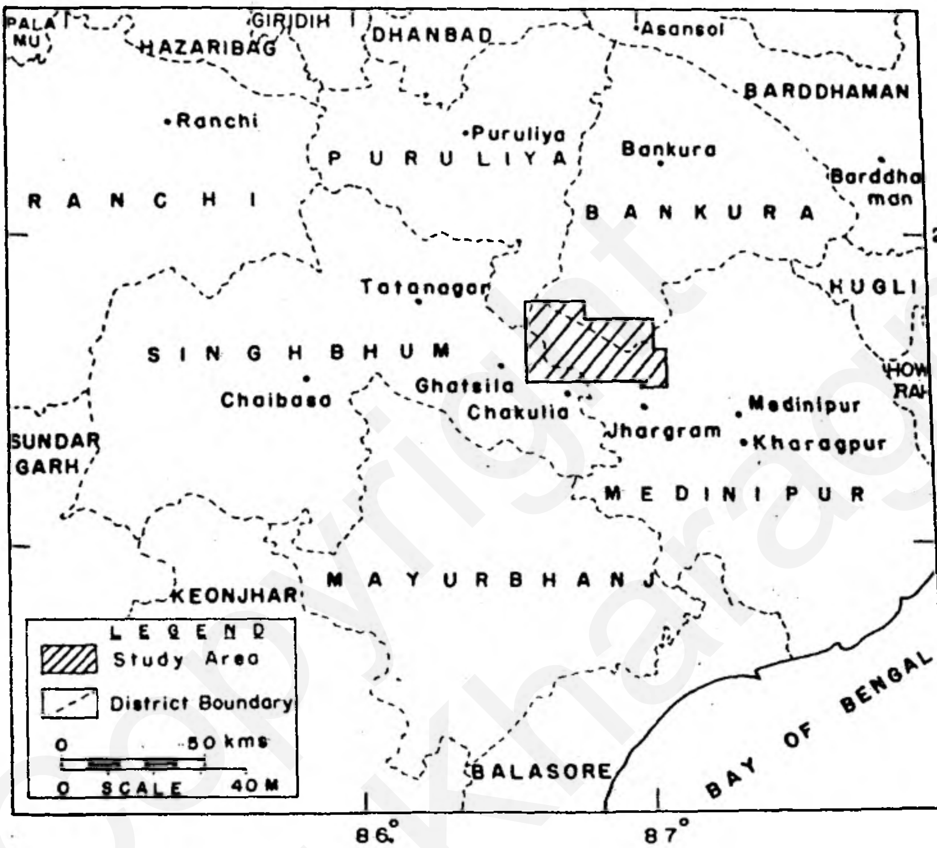

FIG. 11

LOCATION MAP OF THE AREA

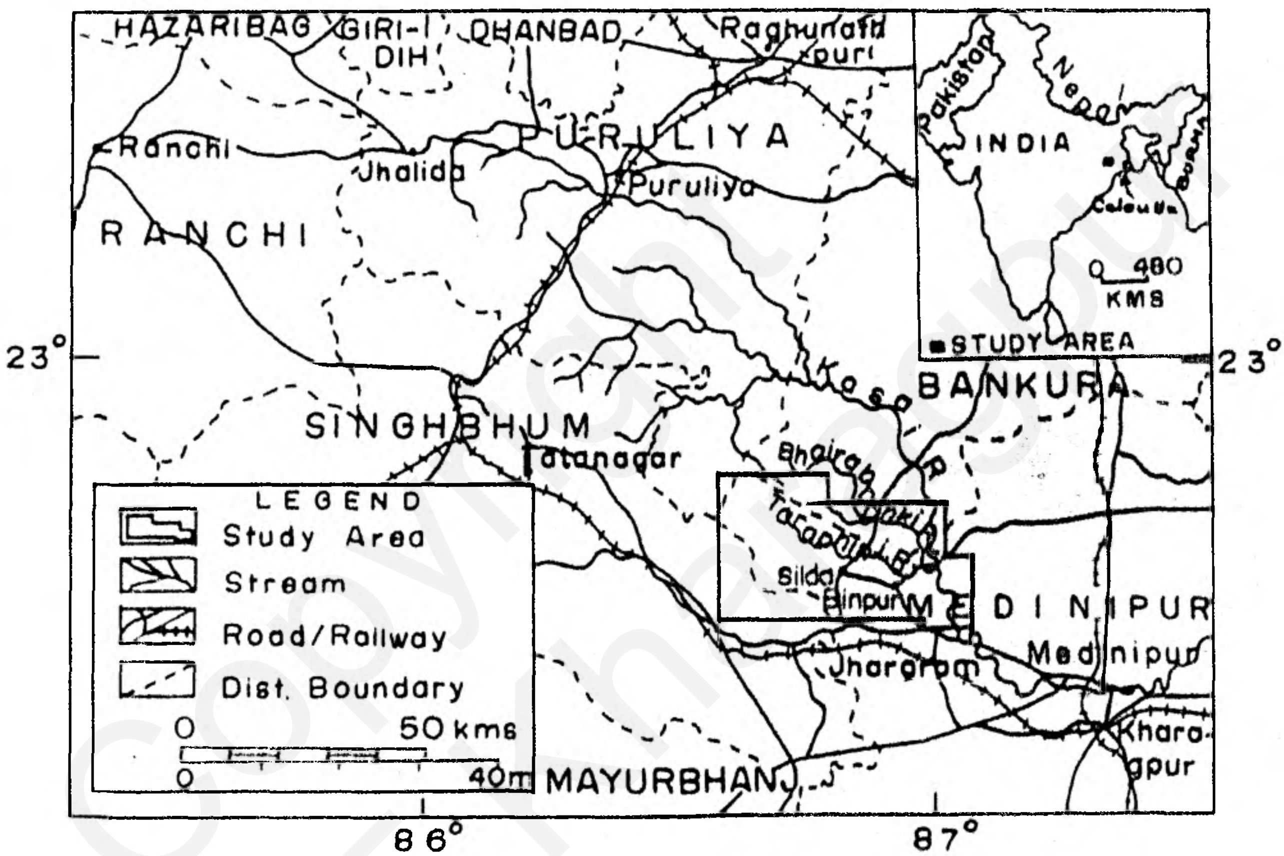

FIG. 1·2

In the year 1978 there was a devasting flood in the Kangsabati Basin. Major parts of the Medinipur District were affected by this flood and large areas were submerged. Both the rail and road links between Kharagpur and Calcutta were snapped for about a month. This catastrophy focussed the need for flood mitigation studies, and the present study on the interrelationships of basin characteristics and floods was initiated in 1979.

On the basis of an agreement on a joint activity on "the application of remote sensing on flood mitigation studies in West Bengal" reached between the Space Applications Centre, Indian Space Research Organisation, Ahmedabad and the Indian Institute of Technology, Kharagpur, low-flying imagery (black and white, colour infrared and 4 band MSS) of the Taraphini Basin, West Bengal, was arranged by the Space Applications Centre, in May, 1979.

The drainage basin is the basic areal unit in which the geomorphic features and land use can be determined. The assessment of these watershed parameters is important because these are intimately related to the basin water and sediment yield. The hydrology of an area depends basically on its climate, topography and geology. The objective of geomorphological studies related to basin characteristics is to evaluate the drainage network of the basin in its entirety. Such categorisation would be helpful in using the hydrological data of one basin in another of similar characteristics, provided other climatic and geological characteristics are identical. This study has concentrated on quantitative landform analysis as applied to normally developed watersheds in which running water and associated gravitative movements, acting over long periods of time, are the chief agents in developing the surface geometry. The combined effects of climate and geology on a catchment topography yield an erosional pattern which is characterised by a network of channels and streams. The author has tried to demonstrate that the average stream pattern is governed by a limited number of independent parameters. The author assumes the similarity of effective catchment areas and uses it to explore the details of channel network structure within a given catchment.

The following modes of investigation have been adopted:

(i) Preparation of a geologic map of the area on 1:63,360 scale from remote sensing imagery of 1:60,000 scale along with field checking of limited areas.

(ii) Preparation of a detailed geomorphic map on 1:63,360 scale together with an enlarged map on 1:30,000 scale of a key locality, from remote sensing imagery of 1:60,000 scale, along with extensive ground check.

(iii) Delineation of different land uses with the help of black and white and colour infrared imagery on 1:50,000 scale and to study reflection characteristics of different land cover objects.

(iv) Study of the morphometry of the basin.

(v) Detailed study of a limited area (32.5 sq km) which will serve as 'test area' for thematic interpretation of Landsat digital data of 29th March, 1975.

These studies have led to :

(A) the establishment of the relationship between rainfall and runoff based on catchment characteristics as studied from remote sensing imageries.

(B) some ideas about mitigation of floods.

(C) the establishment of an integrated mode of remote sensing data analysis and the development of software for multi-level remote sensing data analysis involving satellite, air craft and ground level data in an alluvial terrain in a humid tropical climate.

TIME REQUIRED FOR THE INVESTIGATION

Approximate breakup of the time devoted for different facets of the present investigations are:

(a) Preliminary studies and collection of background data ... ... 6 months
(b) Analysis of black and white and colour infrared imagery ... ... 4 months
(c) Fieldwork ... ... 3 months
(d) Finalisation of geologic and geomorphic maps ... ... 6 months
(e) Collection of hydrolgical data and assessment ... ...4 months
(f) Studies undertaken on the analysis of test area data ... ... 3 months
(g) Total analysis and writing ... 1 year and 6 months

As such, the total time required, on a full-time basis, is nearly 4 years.

PREVIOUS WORK ON THE STUDY AREA AND ON RELATED TOPICS

IN INDIA

In India, the field of remote sensing is relatively unexplored. Remote sensing is an extremely invaluable tool for mapping land use/land cover categories and geomorphic elements needed for water resources planning and management.

Geology : Very little published geological work is available on the present area. The area constitutes the eastern extremity of the Precambrian belt of the Singhbhum Thrust Zone. The area was mapped for the first time by Dunn (1929) in the course of regional study of the Precambrian rocks of Singhbhum District. Dunn (1937) undertook a detailed mapping on one inch to a mile scale of the area mainly for exploring the mineral wealth of the rich Singhbhum District. His work covers structure, stratigraphy, petrology and economic resources of the area. In the western part of the area, Mukhopadhyay and Sengupta (1971) undertook detailed structural analysis around Simulpal village.

Geomorphology: In the present area geomorphological work has not been reported. In India, most of the investigations are based on 'physiographic' aspect of landforms (Chatterjee, 1949,1962; Spate, 1954; Banerjee, 1964). Generalized studies of Bengal rivers for various purposes other than geomorphology have been attempted by many authors (e.g., La Touche, 1910 ; Muckerjee, 1938; Majumdar,1942; Bagchi, 1944, 1960; Dasgupta, 1953; Sen, 1956, 1968a, 1968b etc.). A systematic photogeomorphological mapping on 1:63,360 scale in parts of the States of Orissa and West Bengal has been undertaken in the Department of Geology and Geophysics, Indian Institute of Technology, Kharagpur, in which the regional aspects of the fluvial and coastal landforms have been considered (Niyogi and Chakraborty, 1967; Niyogi et al., 1968; Chakraborty, 1968; Bhattacharya, 1970; Mallick et al., 1970; Niyogi, 1970a,1970b,1970c,1970d; Niyogi and Bhattacharya, 1968). Vaidyanadhan (1964,1965, 1967,1971) has carried out detailed photogeomorphological studies in various parts of India. Prudhvi Raju and Vaidyanadhan (1978a,1978b,1981) studied photogeomorphic features in Visakhapatnam District of Andhra Pradesh. Manchanda (1983) studied aerial photographs of Haryana and investigated the relationship between land type and sub-soil water and salt accumulation in soils.

Land Use and Agriculture: In the present area land use study has not been reported. Though some work has been reported from black and white imageries in India, not much work has been done using colour infrared imageries. Raghavswamy and Vaidyanadhan (1980) carried out detailed land use studies using low flying imageries. Singh et al. (1983) and Saxena et al.(1983) have applied remote sensing techniques for land use mapping with particular reference to agricultural aspects. Gautam and Narayan (1983) identified the land use features using multispectral scanner (MSS). Their main objective was to prepare a small-scale land use map from satellite imagery showing the broad distribution of land use patterns to serve as a base for monitoring land use change. Sahai et al. (1983a,1983b) have carried out ecological studies through remote sensing techniques.

Morphometric Analysis: In India, not much work has been reported on the morphometric analysis of drainage basins. Gupta and Mehta (1980) conducted hydrological studies in the Banganga River Basin as a part of groundwater resource evaluation studies; morphometric analysis of four sub-basins were carried out by them. Raghavan et al. (1983) have done drainage analysis in Trichinopoly District of Tamil Nadu. Anjaneyulu (1983) carried out hydrogeological investigation in the Gadidala Vagu sub-basin in Guntur District of Andhra Pradesh with the help of aerospace data. Agarwal and Sinha

(1983) undertook quantitative morphometric analysis in Asan and Song Basins of Doon Valley of Uttar Pradesh; photogeomorphic analysis were carried out by them mainly to determine the morphometric characteristics and drainage pattern.

Estimation of Runoff : Except for the conventional hydrological investigations, previously no photo interpretation work has been reported from the study area or from any other part of the country.

OUTSIDE INDIA

Geology and Geomorphology: Geologists and geomorphologists have been prolific users of remote sensing outputs. Only a few references have been mentioned. Several journal articles and government publications dealing with photogeology-geomorphology, although published before 1960, are very informative (Wasem, 1949; Desjardins, 1950 and Tator, 1958). An air photo index to landforms in the eastern half of the United States was compiled by Keifer (1967). Badgley and Vest (1966) enumerated the various possible applications of the several remote sensors which are being vigorously investigated by and for space scientists. They include under infrared photography composition (bedrock types, porosity, permeability), structure (faults, folds), sedimentation (dunes, alluvium, etc.), mineral exploration, engineering problems, and crustal studies (volcanoes, heat balance). Sabins (1967) has published a case-history report on the photogeologic applications of infrared photography. According to him, it was possible to distinguish not only between unconsolidated materials (e.g., alluvium) and bedrock (cool/dark-toned versus warm/light toned), but also between different types of strata- sandstone (warmer/lighter) and siltstone (cooler/darker). Rowan et al.(1976) have discriminated major rock types in the south-central Nevada by using both digital processing and colour compositing of ERTS Multispectral Scanner images. Barzegar (1979) evaluated the capabilities of Landsat data for rock type discrimination using enhancement techniques. Rabchevsky et al., 1979 carried out geological reconnaissance of the Washington, D.C. area using remote sensing techniques. Stancioff and Hill (1979) carried out satellite image analysis for mineral exploration.

Land Use: Outside India, land use or land cover mapping using remotely sensed data is a routine practice. Much work has been done on agricultural land use because of the importance of agriculture in the economics of developing countries. Colwell (1962), Neumann and Simonett (1970) have analysed colour, colour infrared and black and white photography in land use studies. Olson (1967) evaluated the accuracy of land use interpretation from thermal imagery. A good amount of work has also been done on the vegetation mapping using colour infrared photographs (Nielsen et al., 1971; Gammon et al., 1979). Studies by Simonett(1969), Rudd (1971), Thrower (1972) are among those that have been attempted on the evaluation of the land use mapping capabilities of small-scale space imagery.

Morphometric Analysis : Horton (1945) undertook the pioneering quantitative description of stream morphology. Ordering of different stream systems has been proposed by him in order to give a better quantitative description of natural stream networks. He laid the foundation for much of the subsequent work in quantitative geomorphology of drainage basins. His quantitative description of landforms paved the way for great advances in the fields of geomorphology, hydraulics and hydrology. Because of complex nature of stream networks, the stochastic approach has been suggested by some researchers to give a probabilistic description of the nature of streams. Horton's work was supplemented by Langbein (1947). Later Strahler (1952,1957,1958), Schumm (1956), Melton (1962), Shreve (1969) and others developed quantitative methods by adding new parameters and investigating regional variations in morphology in a wide range of geologic and climatic environments.

Estimation of Runoff : Some published work on the estimation of runoff using curve number technique is available. This method has been advocated particularly by agricultural scientists who have been using this technique for small watersheds. Cooley and Lane (1980,1982) developed curve numbers for sugarcane and pineapple fields of Hawaii.

CLIMATE AND SEASONS

The area under investigation lies to the south of the Tropic of Cancer and falls within the tropic zone. The climate of the district is characterised by an oppressively hot summer, with high humidity nearly all the year round and well distributed rainfall during the monsoon months. The cold weather starts from about the middle of November and lasts till the end of February. The period from March to May represents the summer. The southwest monsoons are active from June to September and the interval from October to the first half of November constitutes the monsoon recession period.

TEMPERATURE

Temperature starts rising rapidly from the beginning of March. The summer heat is particularly oppressive due to high moisture content in the air. Occassionally, the maximum temperature rises to about 47° C or 48°C. There is a welcome relief from the humid heat, - although only temporarily, - when thunderstorms occur during

March-May. With the onset of the southwest monsoon by about the first week of June, the day temperatures drop appreciably but the night temperature continues to remain high. Because of oppressive humidity, the weather is often very uncomfortable during the monsoon season, especially in between succeeding spells of rain. The monsoon withdraws early in October when temperatures begin to fall. The drop, particularly in the night temperature, is more marked from about the middle of November. December is the coldest month in the area, with a mean daily minimum temperature of 12° to 13°C. The minimum temperature sometimes goes down to 5° to 6°C.

RAINFALL

The nearby meteorological observation station (recognised by the Indian Meteorological Department)is at Medinipur. Belpahari also has a raingauge station which is under the Department of Irrigation and Waterways, Government of West Bengal, but standard information is available only at the Medinipur observatory. The average annual rainfall and temperature of the Medinipur station has been represented in Fig. 1.3.

The area receives a high amount of rainfall. The average rainfall during the monsoon months, June to September, constitutes about 78 percent of the annual precipitation. July and August are the rainiest months. The variation in the rainfall from year to year is not significant. The average annual rainfall in the district is 1525.5 mm whereas at Belpahari it is 1481.75 mm. The concentrated rainfall in the rainy season together with a dry winter and relatively dry summer is characteristic of this monsoon-type humid tropical climatic region. Due to this, seasonal fluctuation of the water table is also considerable; it is lowest in the month of May, just before the onset of the monsoon and rises rapidly during the rainy

AVERAGE ANNUAL RAINFALL AND TEMPERATURE OF THE MEDINIPUR DISTRICT

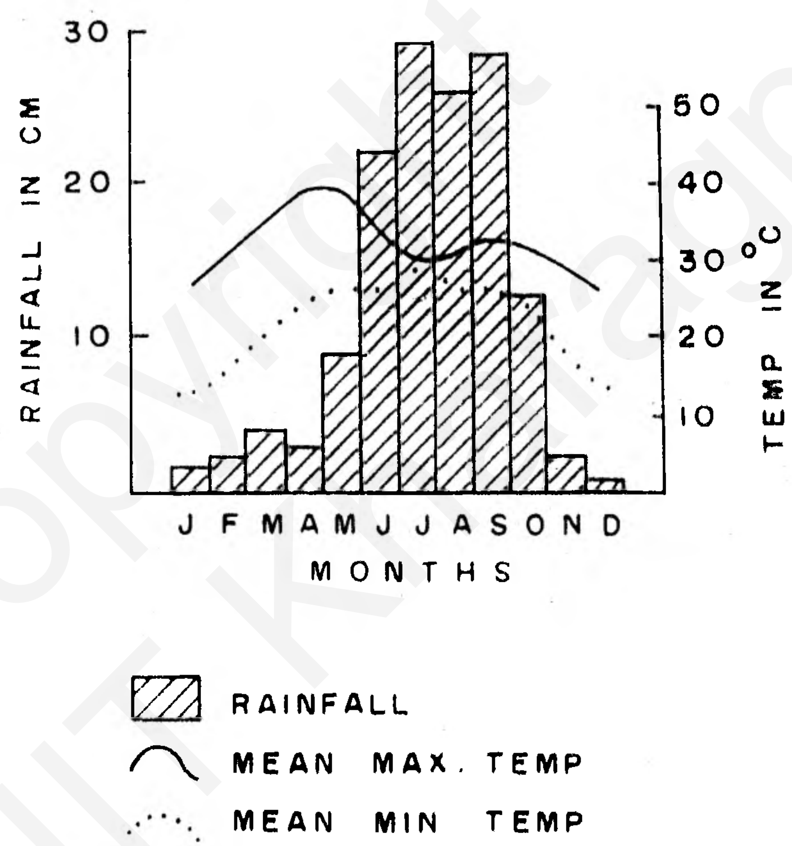

FIG. 1·3

season. Water table is highest in the end of the monsoon after which it gradually falls being lowest again in May. The seasonal fluctuation of the water table possibly favours a lateritic type of weathering.

HUMIDITY

Relative humidities are generally high throughout the year. But in the summer months, afternoon humidities are comparatively less.

Data for temperature, rainfall, relative humidity etc. were collected from the office of the Indian Meteorological Department, Calcutta through the courtesy of the Regional Director.

METHODS AND PROCEDURES OF STUDY

Black and white photographs of the entire Taraphini Basin have been studied in detail in the laboratory and detailed geologic, geomorphic and land cover maps on 1:63,360 scale have been prepared. The first step in this was the preparation of a mosaic to get an overall view of the area, identification of features and understanding their interrelationships. Photogeomorphic analysis was carried out chiefly to determine the morphometric characteristics and drainage pattern. Detailed drainage basin map with all the sub-basins have been prepared on 6.3 cm to one km (1:16,000 approx.) scale. The area of sub-basins of a given order were measured by planimeter from a map on which the perimeters have been outlined for each order and the channel lengths were measured with chartometer (map measurer) directly from the prepared map. The mapping was originally undertaken on 1:60,000 scale visual imageries. The photogeologic, photogeomorphic, drainage and land cover details were studied initially on the scale of air photos and were later projected with the help of sketchmaster on the topographic base of 1:63,360 scale. Various criteria including relief, photo tone, and texture were used to differentiate rock types along with trends of foliation planes and the directions of dips. A detailed photogeomorphic map along the R. Kasai have been prepared on 1:30,000 scale. For both geomorphic and lithologic mapping, the individual landform features and rock types interpreted in the laboratory were later verified in the field and corrections necessitated during field check were incorporated in the map. Colour infrared imageries on 1:50,000 scale have been enlarged to 1:10,000 scale on Zoom Transferscope and projected on a topographical base (original scale 6.3 cm to one km or 1:16,000) also enlarged to 1:10,000 scale, and a detailed land use map of a part of a unconsolidated and alluvial terrain has been prepared. More detailed land use maps of 3 villages have been prepared on approximately 1:2230 scale, representing an enlargement of nearly 1:22 times.

Detailed land use and geomorphological maps of the Lalgarh Test Area has been prepared from 1:25,000 scale black and white air photographs. Digital analysis of the Landsat imagery of 29th March, 1975 has been undertaken and a comparison of geomorphological and land use information obtained from Landsat imagery and aerial photographs was made.