BANGLADESH ERTS (LANDSAT) PROGRAMME
SCIENCE AND TECHNOLOGY DIVISION
CABINET SECRETARIAT

A REVIEW OF BANGLADESH ERTS (LANDSAT) PROGRAMME AND A REPORT ON ITS ACTIVITIES

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Cabinet Secretariat
Science & Technology Division
Bangladesh Landsat Programme
House No.605, Road No.18
Dhanmondi R.A.,Dacca,
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15. ABSTRACT: Bangladesh's participation in the LANDSAT-2 Programme was a continuation of its activities that started in 1972 with the launching of Landsat-1. Because of country's preoccupation with the task of restoration of economic activities during the early days of LANDSAT-1, it was not possible to participate fully in the programme. LANDSAT-2, therefore gave a chance for the continuity of efforts by the Bangladesh LANDSAT Programme started in 1972. An independent centre for the

LANDSAT studies have now been established under the Science and Technology Division, Cabinet Secretariat, Government of Bangladesh. The Programme that started originally with six sectors was expanded to eight sectors. With the inclusion of Statistics sector and separation of Oceanography from Fisheries sector, this number will rise to ten. The ultimate aim of the Sensing Organisation (SPARRSO) in the country, and LANDSAT Programme will be the necleus of this organisation. The Programme in its present form was reviewed by the National LANDSAT Committee and the approved report has been published in printed form. This report containing 66 pages is enclosed and this contain the details of this final report for LANDSAT studies in Bangladesh.

ENCLOSURES: Bangladesh ERTS(LANDSAT) Programme

A Review of the Programme — Printed Report in 66 pages.

&

A Report on the Activities

PROBLEMS: Bangladesh requires real-time data for study of many of its dynamic problems such as flood forecasting, coastal-zone monitoring, river mapping, seasonal variation in water flow, disaster signalling, etc. The data from LANDSAT-1 or LANDSAT-2 were never received on real-time basis, rather they were delayed by months. Such delays had quite retarding effects on many interesting studies. To improve this situation acquisition is of the data locally is a must

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A REVIEW OF THE PROGRAMME

AND

A REPORT ON THE ACTIVITIES

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1. BACKGROUND OF THE ERTS (LANDSAT) PROGRAMME

1.1. Introduction:

The Earth Resources Technology Satellite (ERTS) Programme is a major step in the merger of space and remote sensing technologies into a Research and Development (R&D) system for developing and demonstrating the technique for efficient management of the earth's resources. To demonstrate the usefulness of these techniques, National Aeronautics and Space Administration (NASA) of USA launched two experimental satellites ERTS 1 and 2 in July, 1972 and January 1975 respectively. These satellites were subsequently renamed as Landsat 1 and 2 by NASA. The orbital parameters of Landsat 1 and 2 are almost identical. The satellites are moving in a near polar orbit about 560 miles above the earth's surface and circling the earth in 103 minutes (time period). They complete 14 revolutions round the earth in 24 hours. Each satellite has the capability of taking 752 imageries (in 4 spectral bands) of the earth every day and each shot covers an area of 115 miles square. Because of the timing of its sun synchronous polar orbit, each satellite passes over the same spot on earth at almost the same hour (9-30 a.m. local time) every 18 days. With two LANDSAT satellites now orbiting the earth, the pictures of same area of the earth are available every 9 days.

1.1.1.—The scientific mission of this ERTS (Landsat) Programme is to provide the repectitive acquisition of high resolution multispectral data of the earth's surface on global basis and to supply data to all nations participating in it. These data are available on sale from EROS Data Centre, Sioux Falls, South Dakota, U.S.A. The data collected by these satellites during the last five years have been utilised by many nations in the fields of agriculture, water resources, forestry, cartography, geography, geology, fisheries, oceanography, marine resources, disaster warning and assessment, etc.

1.1.2.—Realising the importance of this new technology, Bangladesh became interested in taking part in LANDAST (then ERTS) Programme as early as in 1970. NASA was intimated and a proposal was prepared. War of independence, however, put a halt to the programme in the country. Immediately after independence, the enthusiasm was revived. A summary proposal was prepared hurriedly and sent to NASA in March, 1972 just before the launching of the first ERTS Satellite. This was a comprehensive programme and was accepted by NASA. Unfortunately it was not possible to take full part in the programme during the early days of LANDSAT 1, as the nation was then recovering from the wounds of the war of independence. Although it was not possible during those early days to participate fully in the programme, Bangladesh started receiving the LANDSAT 1 imageries from February, 1973 and stored them tentatively in the UN/OTC Advisor's office. These Imageries were, however, used by some enthusiasts associated with the programme and a few maps, mosaics and reports were prepared. These activities of the enthusiasts drew the attention of the administration and in January, 1974 a national programme was chalked out and approved by Government. A National ERTS Committee for policy matters

and Inter-ministerial co-ordination was formed in March, 1974. For execution of the programme, a Principal Investigator was appointed and a Task Force was constituted immediately thereafter. After several sessions of the ERTS (Landsat) Task Force meetings, a comprehensive multisectoral programme was again prepared. On approval of this programme by the National ERTS Committee, it was sent to NASA in May, 1974. This programme was accepted by NASA in 1974 and an agreement was signed, between NASA and Bangladesh ensuring Bangladesh's formal participation in the programme.

1.1.3.—Initially the Bangladesh Programme started with six sectors, viz. Agriculture, Water Resources, Forestry, Fisheries and Oceanography, Cartography and Interpretation Techniques Development. Later on, two new sectors—Geology and Meteorology were included. There are now (**Appendix II**) 25 members in the Task Force with the Principal Investigator as the Chairman. All these members are investigators of their respective sectors and they have been nominated by the participating organisations which include Agriculture Department, Water Development Board, Forest Department, Space and Atomospheric Research Centre (SARC) of BAEC, Survey of Bangladesh, Fisheries Department and Geological Survey of Bangladesh. In each sector there is one Chief Investigator, one investigator and one co-investigator. They are all assigned to the Task Force as part time investigators to work in the programme in addition to their normal duties in their respective departments. The Task Force members have been performing their function satisfactorily against stress of over work, but with increasing activities in the LANDSAT Centre it was felt that some full time investigators are required in the Programme to act as the core of the programme for co-ordination and management of its multisectoral activities. Accordingly provisions for three full-time investigators and some supporting staff were made in the scheme for Bangladesh ERTS (LANDSAT) Survey Programme which have been approved by the Government. While most of the supporting staff are already in position, the full time investigators are in the process of being absorbed soon. The organisational structure and flow chart for Bangladesh ERTS (LANDSAT) Programme is shown in **figure 1.**

1.2. Techniques:

The techniques for resource information gathering by ERTS represent a major technological advance in the field of remote sensing. The new elements are the use of space platform (satellite) instead of aircraft and the use of multispectral scanner (MSS) in place of the conventional photographic camera. MSS has the capability of taking pictures of the same spot in four different spectral bands (two in visible and two in solar reflective infrared portions of the electromagnetic spectrum) simultaneously. Consecutive pictures have 10 per cent. overlap on north-south frames and 20 per cent. overlap on the east-west frames at Bangladesh's latitudes. Due to these overlap in consecutive frames, it is possible to prepare mosaic maps on global basis as well as on country basis. The whole of Bangladesh is covered by about 16 frames in five successive days as illustrated in **figure 2.** For three days four pictures are available per day and in the other two days only two pictures a day are taken. This sequence of five days' coverage of Bangladesh is repeated over 18 days for one satellite and every 9 days for two satellites.

1.2.1.—The synoptic view of large area (115 miles square) covered by Landsat picture and taken under fixed solar illumination and from near vertical (orthographic) perspective, makes it particularly valuable for cartographic purposes and for recognising indications of large scale geologic features and vegetation patterns difficult to detect by other means. The repeated coverage every 18 days (or every 9 days since the launch of Landsat 2 in January 1975) of the same part of the earth's surface provides an unequalled opportunity to monitor dynamic phenomena, such as changes in vegetation cover, surface water distribution, flood conditions, changes of river courses, etc. The sequential nature of images also helps in acquiring multi-date data needed for more exact identification of static resource features. As the landsat pictures are taken at approximately 9·30 a.m. local time throughout the world, the known sun-angle and uniformly vertical perspective make possible image mosaics on a continental scale and the overlay of scenes taken on different dates to permit precise comparison.

1.2.2.—Landsat data have limitations that they cannot penetrate clouds and their resolution is limitted to 280′×280′ which is not always favourable for identification of features less than one acre in size. Since conventional methods of resource survey are time consuming, laborious and expensive the synoptic view and repeated coverage of Landsat data provides an unique opportunity for assessment of natural resources, when used in conjunction with aerial photographs and ground observations in same test sites.

1.2.3.—At present, Landsat data reception stations and data distribution centres are operating in USA, Canada, Brazil and Italy. One such station is under construction in Iran and several more are planned. The satellite data are available in the form of photo-imagery and computer tapes from these stations. These data products are analysed by visual interpretation techniques and by the use of computer processing methods and useful information for a broad range of resources disciplines and management requirements are acquired and used.

1.3. **Applications:**

The multi-date and multi-colour Landsat imagery has wide applications in resource evaluation, planning, management and development. Significant results have been obtained globally in the fields of agriculture (crop acreage estimation, yield forecasting, soil mapping, etc.), rangeland management, forest resources survey, water resources management (surface water distribution, major watershed characteristics, etc.), geologic survey and mineral exploration, cartographic mapping, land-use planning, marine resources survey, disaster warning and assessment, etc. This is a new technology and there is global awareness in harnessing benefit out of this new technology. Bangladesh became associated with this programme since the beginning and inspite of limitations has made some useful utilisation of this new technology in the country. A brief account is given in the following sections.

2. PROGRESS OF WORK AND PRACTICAL APPLICATIONS

2.1. Introduction :

LANDSAT 1 (then ERTS 1) imageries first arrived in Bangladesh in early 1973, when two sets (12 and 13 each) of coloured slides and a few black and white prints of some Bangladesh scenes taken by Landsat 1 since October, 1972 were received by Mr. F. Z. Kutena, UN/O.T.C. Adviser to Bangladesh Water Development Board. Bangladesh was then only programming for participation in the ERTS Programme and was not fully participating in it. NASA was, however, taking photographs of Bangladesh with its satellites for interests shown by Bangladesh earlier. Some of these photographs came to Mr. Kutena then advising the Bangladesh Planning Commission who were initiating a Bangladesh ERTS Programme with Dr. Anwar Hossain as the Principal Investigator. These early imageries raised enthusiasm in the country and a few pioneering interpreters started analysing them within the limitted scope of facilities available in the country and some interesting results were obtained. These early achievements were acclaimed nationally and also at international level. The programme, therefore, got an enthusiastic start. Though the programme is yet to function with full facilities the progress of work and the activities of the programme is quite satisfactory. Some of the major activities of the programme is described below.

2.2. Land accretion map of the coastal area in the Meghna estuary and the Land-use studies in Chittagong and Chittagong Hill Tracts :

This was the first ERTS studies carried out in the country. The first set of slides and photographs received through Mr. Kutena were used. As there were no sophisticated instruments to analyse the data, visual interpretation of land formation, sedimentation patterns and land use classifications were carried out using ordinary slide projector. The slides were projected on the wall with an ordinary slide projector and the delineations of different coloured patterns were made with a pencil on drawing sheets hung on the wall. Six slides were projected separately and the delineated details were then transferred with slight adjustments into one tracing sheet. The consolidated details accumulated in a single tracing sheet was further improved by visual ovbservations of the few black and white prints received with the slides. The details in the map thus prepared were all hand drawn from slide projections. No precise and Sophisticated mapping equipments were used. It was, however, interesting that even with all such improvised mapping arrangements, LANDSAT imageries have been transferred into useful maps with revealing details in about 16 man-hours of spare time and it was found to compare favourably with any existing maps which took years for preparation and provided an excellent pictorial review of the land resources of this region (**Figure 3**).

2.2.1.--In this map, a broad land-use classification was made, Dry hill areas with grass and scattered vegetation was separated from wet forest cover. Karnafuli Hydel lake was for the first time delineated accurately, clearly showing no inundation beyond Bangladesh's territorial boundary, thus putting an end to a controversial matter of discussion. The Aman crop (second seasonal rice crop) areas in Halda and Ichamati basin and

in the flood plains of Anwara and Boalkhali in Chittagong district could be identified. Coastal flood plains of Sitakunda and Mirershorai could also be located . It was also possible to identify the new coastal formations outside coastal embankment in the Noakhali district. The most revealing information however, came from the Bay of Bengal. The offshore islands were seen to be completely different in cartographic outline in this map than that found in older maps. Some of the silt deposition in the Bay that were identified and delineated as suspended sediments were subsequently found to be new land under formation. This finding itself was a discovery in the sense that never before this aspect of the coastal morphology was seriously taken up for study till this revealing information came out of this pioneering LANDSAT imageries study. This discovery not only brought with it a great hope and unending expectation to the country's ever-expanding land need, but also gave a real boost to the dormant LANDSAT Programme. The programme came to lime light with this finding and attracted national attention.

2.3. **Preparation of uncontrolled mosaics using Landsat imageries:**

2.3.1. The first uncontrolled mosaic of Bangladesh was prepared in April, 1974 using the black and white 9″×9″ photographs of Bangladesh scenes (**Figure 4**). These printouts were produced in Bangladesh from the 9″×9″ negatives supplied by NASA using locally manufactured contact printer available at the space and Atmospheric Research Centre (SARC) of Bangladesh Atomic Energy Commission. Since this was the first photo map of Bangladesh produced in the country using satellite images it revealed some interesting cartographic details which were missing in the maps available in the country that were produced by traditional mapping methods. Time taken to produce such photo map and also the possibility of repeating the mapping every 18 days was an interesting advantage that drew every body's attention in the country.

2.3.2. Since the preparation of this map, a number of mosaics have been prepared at different dates using printouts of different bands and different seasons (**Figure 5**). The cartographic variations were studied to yield many more revealing details including surface water distributions at various seasons, erosions and sedimentations in the rivers at various seasons, forest covers in important forest areas of Sundarbans and Chittagong Hill Tracts, soil and geologic features, etc. These maps have been used by various sectors of the Bangladesh ERTS (LANDSAT) Programme as base maps for interpretation.

2.3.3. World Bank has prepared a coloured map mosaic of Bangladesh in the scale 1·500,000 using ERTS imageries. The Bank has also prepared mosaics in the same scale using bands 5 and band 7. These maps were delivered to the Bangladesh LANDSAT group by Dr. Wolfrum Drews during his visit to Bangladesh in 1974. They are now being used by the various sectors as base maps.

2.4 **Land accretion studies in Patharghata in Patuakhali district:**

An ecological study in the Patharghata Police-station of the Patuakhali district was undertaken in 1974. LANDSAT images were used to map the newly accreted land between Patharghata and Laldia island. The morphological changes were studied using aerial photographs of the area taken

during 1963 and 1975. It was found that in aerial photographs of 1963, there is clear sea between Laldia island and the mainland of Patharghata. Afforestation programmes were started on the embankments that were raised all round patharghata as jacket plantations and also as protective shelter belts outside the embankment. It was found that a morphological change occurred during the period from 1963 to 1969 and there were heavy siltation beyond the forests and the embankments. By 1975 the entire area was filled up and a mud flat connecting the Landia island and the Patharghata was formed. An area of 50 square miles of mud flat observed in LANDSAT images of 1973 was subsequently mapped with aerial photographs taken in 1975 (**Figure 6**) and was followed by ground truth confirmation by ERTS Task Force members. This area is now under forest cover and the newly accreted mud flat is being afforested.

2.5. **Mapping for coastal afforestation Programme:**

Coastal area of Bangladesh has been subjected to ravages by cyclone and tidal surges from times immemorial. The colossal damage to property and loss of human life during the cyclone and tidal surges of early 1960's drew wide attention and large scale embankments were raised all over the south edges of Bangladesh that faces the Bay of Bengal. These embankments needed jacket forest plantation on them and shelter bolts outside to protect the embankments from wave action at the time when cyclonic surges hit the embankments. A massive coastal afforestation programme was, therefore, started from 1964. While planting the embankments and the water fringes with forest trees and shelter belts it was revealed that new accretions coming out in the areas adjoining the embankments also need to be planted up with trees for protection and consolidation. Then came the revealing discovery that new land is being formed in the Bay. This increased the activity of the coastal afforestation programme of the country. For proper planning and accurate formulation of action plans, including coastal afforestation, maps of these areas became an urgent necessity. Such maps were neither available nor it was possible to undertake such mapping work with conventional mapping technique available in the country. Forest Department who were responsible for the afforestation activities also needed maps for getting some legal control over the newly formed land to enforce protective measures and to allow natural succession of vegetation in these new lands. A map mosaic of the coastal area of Bangladesh in ERTS band 6 showing the latitudes and longitudes between which the possible areas fall was prepared and supplied to the Department of Forestry (**Figure 7**). The Department of Forestry used this map in initiating their case to obtain a legal support in the areas indicated in this map with latitude and longitude references as follows:—

District	Latitude	Longitude	Area
Chittagong	.. 22°45′ N	91°15′ E	1,95,000 acres.
	20°30′ N	92°30′ E	
Noakhali	.. 22°30′ N	91°00′ E	4,50,000 acres.
	21°30′ N	91°30′ E	
Barisal	.. 22°30′ N	90°15′ E	3,60,000 acres.
	21°15′ N	91°00′ E	
Patuakhali	. 22°00′ N	90°45′ E	2,25,000 acres.
	21°15′ N	90°15′ E	

Ministry of land Administration and Land Reforms were approached with these ERTS maps forming the basis. This was accepted and a notification has since been issued by the Forest, Fisheries and Livestock Division, Ministry of Agriculture declaring the areas referred in the LANDSAT mosaic with latitude and longitude boundaries as protected forests. Bangladesh LANDSAT Programme has now undertaken a programme of mapping all the newly accreted land in collaboration with scientists from Environmental Research Institute of Michigan (ERIM). A ground truth mission team from the Bangladesh Task Force and ERIM scientists went to the Bay of Bengal in Fisheries Department's research vessel 'Maach Ranga' in November, 1977. Many interesting observations have been made and bathymetric and oceanographic data have been collected. These are now being analysed at the LANDSAT Centre and in ERIM. It is expected that by mid 1978, a qualitative and quantitative mapping of the coastal area will be completed and a detailed map will be available. Meanwhile a theoretical model for the coastal Land accretion has been prepared and this will be tested with ground truth observations.

2.6. Base line map of Bangladesh coast :

The Islamic Foreign Minister's Conference and the UN Conference on Law of Seas discussed a number of times about the coastal base line of individual countries. Government of Bangladesh presented papers supporting her views on base line delineations in these conferences. For these papers the Ministry of Foreign Affairs and the Bangladesh Inland Water Transport Authority required mosaics of the coastal areas of Bangladesh. These mosaics were prepared using different bands of ERTS imageries and were supplied timely. In April 1977, 500 printed copies of such mosaics were required for 3rd UN Conference on the Law of Seas held in New York for incorporation in the country report. These were prepared in Band 4 and the base line was shown along the sedimentation boundary (**Figure 8**). This work of the ERTS Task Force was well appreciated by the Ministry of Foreign Affairs and also by the Ministry of Communications (Port, Shipping and Inland Water Transport Division), Government of Bangladesh. This base line was ground truthed in November, 1977 in an expedition carried out jointly by Bangladesh ERTS Task Force Team and UNDP/FAO/ERIM experts. It was found that the sedimentation line that was shown as the base line is at 5 fathom depth only where occasional shallow shoals were observed, whereas the 10 fathom line is well outside the base line shown in this mosaic. Thus the base line shown coincides with sedimentation line and truly depicts end of the territorial land boundary. Further verification is necessary through hydrographic survey to fully establish the claim. ERTS mosaic provided by the Task Force may be used as the base map for any further study in this respect.

2.7. Land-use Maps :

2.7.1. Land use maps of Sylhet, Mymensingh haor (low lying) area has been prepared at a scale 1:50,000 using Landsat imageries, aerial photographs and ground observations of specific test sites (**Figure 9**). Two photographs of Landsat 1 of Haor area in black and white print in MSS 7 were studied. One taken in the month of November, 1972 revealed quite interesting details.

The entire boro crop areas were covered by water and pockets of Aman paddy were visible. A big block of Aman paddy in Baniachong P. S. was detectable. The other photograph taken in the month of March, 1973 represented contrast picture. The high land and haor areas were easily detectable. On the basis of different tonal characteristics, the areas were delineated. Ground truth by an aircraft and surface observations were made to confirm the exact use of the land in some sampling areas. Aerial photographs were also consulted. Finally, land was classified and sketched on a known map scale and areas under different categories such as crop settlement, water, etc., were classified.

2.7.2. Preliminary land-use maps of Sunamganj, Baniachog and Srimongal areas in the Sylhet district have also been prepared in the 1,30,000 scale **(Figure 10-12)**. These land-use maps have been used for identification of water bodies, cultivable land, grazing and fallow land, settlement, etc.

2.7.3. A detailed map of DND (Dacca-Narayanganj-Demra) area showing cultivable area, old and recent settlement, water bodies and fallow land have been prepared **(Figure 13)**.

2.7.4. Landsat imageries have been used in locating broadcast Aman area of Baniachong Police-station Estimation of acreages is under study **(Figure 12)**.

2.7.5. These are preliminary attemps towards utilisation of remote sensing technology for the preparation of digital land-use map of Bangladesh for which a programme has already been envisaged and correspondence are underway with IBRD through ERD.

2.8. ERIM/Jahangirnagar University Programmes

2.8.1. In 1974, Environmental Research Institute of Michigan (ERIM) Ann Arbor, Michigan, USA invited Principal Investigator, Bangladesh Landsat Programme to initiate a proposal for a reserach project to be jointly conducted by ERIM and Bangladesh LANDSAT Programme under an USAID competitive grant. This was an open global competition. With a view to associate universities to such reserach studies, Principal Investigator invited the Department of Geography, Jahangirnagar University who had earlier shown their interest in an ecological case study in the Haor areas of Sylhet and Mymensingh to come up with a programme. A programme was then prepared by the University in collaboration with Bangladesh ERTS Programme and was sent to ERIM through USAID. This proposal was approved and Bangladesh was one of the five countries that received this competitive grant. The project envisaged a land-use survey of the low-lying Haor areas of Sylhet and Mymensingh districts using satellite imageries. The purpose is to evolve a data base for optimum utilisation of benefits from the Haors (low-lying area) of Sylhet and Mymensingh districts under this programme. Bangladesh and ERIM scientists have carried out photo interpretation exercises using aerial photographs, they have also visually interpreted the tonal characteristics of the LANDSAT images and have ground truthed over the area in low-flying light aircraft and also through ground visits. The data from these interpretations and ground truth observations have been used for computer processing of Landsat data to map cropping patterns in the area.

The data was classified to show the extent of spring crop which is dependent on the subsiding water of the previous rainy season's flooding. The computer printouts have been produced showing water in blue colour, fallow (dry) land in yellow and different vegetation densities as blue, green, magenta and pink, etc.

2.8.2. Preliminary results of interpretation of these data indicates the following :

(1) Individual cultiavated field are usually smaller than the Landsat pixel size, making individual field identification difficult.

(2) Large fallow areas used for grazing can be separated from actively cultivated (green) fields.

(3) Water areas, some times as small as 5 acres, are correctly recognised and delineated except when covered with aquatic vegetation (often water hyacinth).

2.8.3. This programme is now at the final stages of processing and is expected to yield useful results that may supply keys to further studies using LANDSAT data in the country.

2.9. **Winter Crop Estimation :**

Landsat imageries have also been used for the analysis of winter rice crop area. This was just a preliminary study to assess the possioility of utilisation of Landsat imageries in the winter crop estimation in the country. Aerial reconnaissance flights in small aeroplanes of the Department of Plant Protection engaged in insecticide spraying in the winter crop area helped in collecting the necessary ground truth. Since boro rice (winter rice) crop is a monoculture crop in a vast tract of area in the Sylhet and Mymensingh districts, this study has opened a new possibility for the utilisation of LANDSAT imageries from annual winter crop inventory. A sample winter crop estimation was made in the Sylhet-Mymensingh area. This estimate shows an agreement of about 93 per cent. with 1973 data of Agriculture Department . The results of these studies may be useful for the programme for winter crop estimation that is being undertaken under the sub-contact component of UNDP/FAO project for the Bangladesh ERTS (LANDSAT) Programme. Members of the ERTS Task Force and the experts from ERIM have already started preliminary works in connection with that programme.

2.10. **Geologic feature studies :**

2.10.1. The Brahmanbaria-Noakhali area was chosen as an experimental ground for finding the scope of application of LANDSAT imagery in geomorphic and geologic mapping. It was found that in the plains and piedmont, covered by Quarternary deposits, the imagery furnished useful information on tonal variation and texture. They were particularly useful in the delineation of trend and shape of water bodies. These information when plotted, brought up patterns which significantly aided in mapping, particularly in the classification of mapable units. The satellite imageries (Landsat 1 and 2) of the area in black and white of bands 5 and 7, and in colour of bands

4, 5 and 7 were studied at different scales. Also examination of film positives (70 mm) of the four bands (4, 5, 6 and 7) in the Additive Colour Viewer (used in EROS data Centre, Sioux Falls, SD, USA) and of diazo-prints of the film positives (9″×9″) of those four bands were carried out.

2.10.2. A black and white print of LANDSAT I imagery No. E-1176-03553 of band 5, taken during January 1973 is shown in Figure 15. It shows some of the characteristic features of the area under study such as tonal variation and drainage patterns. It has been found that tonal variation and texture distinguished the present day drainage from disappearing and nearly extinct drainage. In general, fine textured poorly drained alluvium, which is mainly clay, gives dark tone while coarse-grained well-drained alluvium consisting of silt and sand gives a lighter tone. This is an agreement with the observation made by Martin in Missauri, U.S.A. Thus in the Brahmanbaria-Noakhali area, grey tone probably represents predominantly clayey soil (*atale mati* in Bengali), lighter tone, loam (*doash mati*), and the lightest, sandy soil (*balu mati*).

2.10.3. The grey tone is restricted along and at the confluence of some streams and may represent comparatively moisty land, and the lightest tone, restricted to older and drier stream beds having sand splays over both banks. The greyness of the soil may also be relative to its moisture content. Even where loam has appreciable moisture content, a grey tone appears but when dry, it gives a lighter tone. Thus grey tone has developed in soild consisting of silty loam and loam in the western part of the area compared to clayey soil in the east or south. Here, the grey tone is due to higher water retention capacity possibly because of the presence of a hardpan at depth.

2.10.4. A roughly elliptical area, spreading E-W between west of Chauddagram to Matlab Bazar, rather bulging in the sout-west of Barura has a significant darker tone on the LANDSAT imagery. The cause of the darker tone is not clear. Studies of the soil and present day drainage maps of the area have not given any clue. The dark tone may be because of moisture daming due to the presence of a hardpan at depth or caused by a southern tilt along the northern margin of the area (Paranpur-Lalmai-Mangichu Nadi) whereby water passage below the surface is somehow obstructed.

2.10.5. The older courses of streams can be delineated following the trend of settlements (homesteads and tree plantations) soils and vegetation. In most cases, the localization of present-day settlements follows the trend of the old levels lying beside the older courses of rivers and along the scars left by the meandering streams.

2.10.6. Thus the settlements are linear along the levels of the dead and dying rivers, and this lay-out persists through later times, even though no river exists. The former courses of the rivers can be identified by the linear orientation of the remmants of traces of old courses, bils (lakes) and swamp, ox-bow lake and out-off meanders. These features when identified on the space imageries and aerial photogrpahs, have aided in the

identification of former drainage channels. Study of the delineation of the older channels and their relation with the presentday courses of nearby streams has helped in suggesting a sequence of drainage of the area. The levees are comparatively built-up areas on the banks of rivers and are linear in pattern. They are built by sedimentation when the rivers are in spate overflowing the banks.

2.10.7. Mapping with imagery of selected areas in Chittagong, Chittagong Hill Tracts, Sylhet and Dinajpur have also furnished additional information for incorporation in the geological maps of these areas.

2.11. Surface Water Distribution and River Course Monitoring :

2.11.1. The comparison of Landsat imageries of different months show the seasonal distribution of surface water. Systematic studies of the inventory of dry season surface water in the River, haor and bil areas will help in irrigation planning. This study was initiated, but could not be done effectively because at present the Landsat imageries are received from NASA at least three/four months after the satellite passes over Bangladesh. Thus there is a delay between the date of acquisition and date of ground truth measurements. This delay makes the observed features look different when data analysis is attempted. For such a case real-time data is required. Since Bangladesh is not only interested in the optimum utilization of her water resource but also its proper management and control, analysis of ERTS data will yield many positive indications to the water resources management activities in the country. So collection of real time data through a ground receiving station in the country is necessary. The situation will surely improve with the establishment of a Satellite Ground Station in the country.

2.11.2. Landsat imageries have also been used to correct maps of river courses. Courses of the river Bhairab near Khulna, Jamuna near proposed Jumuna river bridge site, Sitalakhya near Kaligongj. Karnafuli in Chittagong and Chittagong Hill Tracts, etc., have been studied and many cartographic changes have been noticed. The navigation routes in the Hatia Channel, Shahbazpur Channel and Tetulia channel down to deep sea have also been studied using LANDSAT images. Continuous observation of these channels and other river courses for delineating safe navigation is being envisaged.

2.11.3. Studies of Padma and Jamuna river has been carried out in synoptic perspective to get the latest position of the river courses and the seasonal variation of water width in these rivers. A Japanese firm engaged in Jamuna bridge feasibility study used LANDSAT images to study the seasonal fluctuations of the beds of Jamuna river for selection of a proper site for the bridge. Sequential study of images of Padma river near Hardinage bridge showed appreciable variations in water flow through the river since 1975 only qualitative observations were made. Quantitative estimation is possible and may be undertaken in future.

2 12. **Development of laboratory facilities and technical capabilities:**

2.12.1. ERTS (LANDSAT) Centre is now equipped with photographic reproduction and enlargement facilities for black and white pictures. Settingup of a colour photo laboratory has also been envisaged during the next one year. Four sets of Diazo Printer and Developer have been installed for producing false colour composites of different bands of LANDSAT imageries. These are now being processed locally and are used for various studies. Aerial photographs of various test sites are being collected from the Survey of Bangladesh and stored in appropriate storing facilities developed in the Centre. Interpretation of these photographs with mirror stereoscopes is being carried out in the Centre. For transferring of details both from satellite images and from aerial photographs, a Zoom Transferscope already installed in the Centre is being used. Cartographic enlargements can be made using a plan variograph available in the ERTS (LANDSAT) centre. A multispectral additive viewer and a Density Slicer with digital attachment are in the process of acquisition. With all these equipments installed, the Bangladesh LANDSAT Centre will become almost self sufficient to carryout many reserach and operational studies using LANDSAT data.

2.12.2. Bangladesh ERTS Programme started with only a few trained personnel, some of the ERTS Task Force members have since been trained up to handle and interpret the imageries. They are also now capable of using the instruments already installed. Available technical capabilities are being expanded through visits and contacts of investigators to different user countries where capabilities have already been developed. Some of the investigators have also attended short training seminars and workshops organised by UNDP and other international agencies. Further training of investigators in different institutions in user and producer countries have been planned and will soon be started. It is expected that with the completion of the first phase of the Bangladesh ERTS Programme which will end in 1978, a group of trained investigators will be available in the country to independently run the second expanded phase which includes the establishment of satellite ground station and regionalization of Bangladesh facilities for ESCAP zone.

2.13. **Seminars and Training:**

2.13.1. It may be interesting to note that when Bangladesh LANDSAT programme was first approved by Government in 1974, the LANDSAT enthusiasts had to struggle hard to explain many basic facts about this new technology to the Government and even to many academicians in the country. It was then felt necessary to generate interest and create awareness in the country in this new technology. To fulfil this objective a seminar on Remote Sensing, the first ever held in the country on this subject, was organised in January, 1975. In all 82 technical delegates from all over the country participated. The crowded opening session was attended by well over 800 persons. In six technical sessions, 22 resolutions were adopted. The seminar generated quite a bit of enthusiasm in the LANDSAT Programme in the country. The proceedings of the seminar that has been published subsequently has been widely distributed. The result is that the LANDSAT Programme is a widely known and well acclaimed programme in the country and with LANDSAT Centre already established and equipped

and with the satellites about to become operational, Bangladesh may take a leading part in the world for the utilisation of LANDSAT data in her resource planning and resource development activities in near future.

2.13.2.—Investigator from Bangladesh ERTS (LANDSAT) Programme participated in national and international seminars and have presented papers on the activities of ERTS Programme in Bangladesh. Some of the investigators have delivered lectures and distributed prepared lecture-notes on Remote Sensing Technology in the post graduate classes of the Universities. This has added enthusiasm in the subject and the curriculam has been expanded to include Remote Sensing and Satellite surveying in regular courses in the post graduate studies. Bangladeshi investigators have also presented speeches, lectures, slide shows on Remote Sensing and Satellite surveying in some meetings of social, scientific and cultural organisations. The Principal Investigator and other investigators have participated in television and radio programmes to explain this new technology, its utility in the country's development.

2.13.3.—A two day seminar/workshop on Remote Sensing and Satellite surveying was organised by Bangladesh ERTS (LANDSAT) Programme in Dacca on July 1 and 2, 1977. Dr. Z. D. Kalensky, Research Scientist, Forest Management Institute, Environment Management Service, Ottawa, Canada was the Principal Speaker. This was principally organised as a training Seminar/workshop for the members of the Task Force of the Bangladesh ERTS (LANDSAT) Programme but officials from concerned Government Department and Autonomous bodies also participated in the Seminar/workshop.

2.13.4.—Bangladesh ERTS (LANDSAT) Task Force assisted USAID in organising the ATS-6 demonstration programme in Dacca on 2nd August 1976 Principal Investigator and two Chief Investigators also participated in the programme which was Telecast in closed circuit T. V. at Dacca, Chittagong and Mymensingh. The Principal Investigator, in fact, exchanged words with his counterparts in USA through this demonstration project.

2.14. Expert services :

2.14.1.—Mr. F. Z. Kutena, UNOTC expert attached to Water Development Board pioneered the introduction of this new technology in the country. In fact the initial planning, organisation, studies, interpretations, and ground truth missions were planned and performed under his expert guidance. The first images from NASA was received through him; he also built up a library on Remote Sensing with literature collected by him. The first image interpretation was done under his guidance and the first ground truth mission in a helicopter was done on 7th February 1973 under his leadership. He also advised in the planning and Programming of the first National Seminar on Remote Sensing and Satellite Surveying held in January, 1975 and also participated in the seminar with presentation of a paper.

2.14.2.—Dr. Norman H. MacLeod, Director, Earth Resources Development Research Institute (ERDRI), Washington D. C. formerly a Professor in the American University of Washington and a NASA medal winner for exceptional

scientific achievement, was available in Bangladesh for a short term consultancy of two months from 8th December, 1976 to 8th February 1977. During his short stay Dr. MacLeod made valuable contribution to the Bangladesh ERTS Programme by imparting training to the investigators in setting the laboratory and the equipment and also in planning the future activities. He also participated in a ground truth mission on 21-22 January, 1977 in the Meghna estuary which was synchronised with the LANDSAT pass over the area. During this trip the Chairman of the Task Force and members of the Task Force walked on newly emerging island in the Meghna estuary which was predicoted by them as possible land accretion two years back. At Dr. MacLeod's personal initiative NASA took photographs of the area at the time the team was visiting the island. This image will be subjected to detailed study soon.

2.14.3.—After completing his short assignment Dr. Macleod went back to USA, but he continued to work for the programme in USA with support from FAO, Rome who are the implementing agency for the Bangladesh ERTS Programme's UNDP component. He arranged selection and ordering of equipment and feasibility of training facilities for Bangladesh investigators.

2.14.4.—Dr. Macleod has returned as long term adviser to the programme in September 1977 and since his arrival, his liasion with UNDP, FAO, NASA and other international agencies has been found to be useful in the smooth implementation of the programme.

2.14.5.—Dr. D. G. Protz of University of Guelph, Canada visited Bangladesh in 1977 as a short term consultant under an IDRC research grant to Bangladesh LANDSAT Programme. Dr. Protz assisted LANDSAT Task Force to prepare a comprehensive plan for the studies of the watershed areas in Chittagong Hill Tracts to find the rate of siltation in the Karnafuli hydro-electric reservoir, and surface water ecological studies in the west and south west Bangladesh.

2.14.6.—Dr. R. A. Pacheco, a Remote Sensing Specialist from the Remote Sensing Unit of FAO, Rome was available in the country for three weeks in September/October, 1977 as short-term consultant. Dr. Pacheco assisted the Task Force in the stratification of all the sixteen Landsat formats that cover Bangladesh and also helped in the selection of a number of test sites for future observation and ground truth. He also delivered lectures to the Task Force on ground truth data collection and landuse planning. Dr. Pacheco's short visit was extremely useful to the Task Force members.

2.14.7.—A team of experts from the Environmental Research Institute of Michigan (ERIM), USA was in Bangladesh from October 22—November 11, 1977. The team was led by Mr. F. C. Polcyn, ERIM's Research Engineer and an expert on Ocean Bathymetry. The visit was in connection with the sub-contract component of the FAO/UNDP project for Bangladesh ERTS (LANDSAT) Programme which has been awarded to ERIM. This sub-contract envisages mapping of the coastal land accretion in Bangladesh, winter crop estimation and also on-the-job training of the ERTS investigators in Bangladesh and in USA. The team organised a half a day lecture programme on the Satellite Remote Sensing and its application on 2nd November

1977 which was participated by members of the Task Force and participants from user organisations. This was a useful introduction for all the Task Force members. The ERIM team then split up into three groups. Mr. Harvey Wagner, a Research Associate and expert on computer processing was assigned to look into the Statistics Division's computer IBM 360/30 to prepare a demonstration programme for Bangladesh investigators at Dacca. In two week's time, he succeeded in training the computer to take a demonstration programme with Landsat (ERTS) Tapes. A second group consisting of Mr. Tom Wagner, a Geomorphologist, Mr. N. Roller, a Forestry Remote Sensing expert and Dr. B. Haack, a Geographer went to ground truth mission in and around Dacca with the Agriculture and Cartography group of the ERTS Task Force. The third group with Mr. F. C. Polcyn went to the coastal area of Bangladesh in Fisheries Department's Research Vessel 'Maach Ranga' and carried out different oceanographic and bathymetric measurements in the Bay of Bengal. The team took measurements and collected samples at different places recorded by Decca readings on board the vessel and went down to a latitude of 21°13½′ which coincides with the 10 fathom lime. The visit was also synchronised with passes of the LANDSAT 2 over the areas between 4-7, November, 1977. The team also visited Sundarbans on 7th November 1977 where Mr. N. Roller, the forestry and wildlife expert joined. A test ground truth survey on forestry sampling was carried out in Shela block of Sundarbans. The data collected by these teams will now be analysed both at Dacca and at ERIM by Bangladeshi investigators under the guidance of ERIM's experts and will result in a number of maps and blow up computor print out that will be useful for country's agriculture, water resources and forestry planning.

2.15. Distribution of ERTS Data:

Landsat data are available to the participating agencies through the investigators assigned to the programme. LANDSAT Data are also supplied to other user organisations whenever it is required by them. The following organisations and agencies have received LANDSAT imageries from the LANDSAT Centre:—

(1) Department of Geography, Dacca University for course work and research.

(2) Department of Geography, Jahangir Nagar University, for course work, research and USAID/ERIM Project.

(3) Department of Water Resources Engineering, University of Engineering and Technology. For course work and research.

(4) Petro-Bangla (oil exploration corporation) for possible use in oil exploration.

(5) Directorate of Land Records and Surveys for use in settlement mapping.

(6) Museum of Science and Technology for display and records.

(7) Special studies Directorate, Water Development Board for studying surface water distribution.

(8) Forest, Fisheries and Livestock Division, Ministry of Agriculture for identification of international boundary in the Bangladesh-Burma-India border.

(9) Ministry of Foreign Affairs and Bangladesh Inland Water Transport Authority for base line map of Bangladesh.

(10) Commonwealth Human Ecology Council-Bangladesh (CHEC-Bangladesh) for case studies.

The images supplied were all reproduced in the ERTS (LANDSAT) photo laboratory and was distributed free of charges.

3. NATIONAL SUPPORT

3.1. The Government of Bangladesh approved the scheme for ERTS Programme in June 1974 with an estimated total cost of Tk. 24·88 lakh (Foreign exchange component Tk. 13·66 lakh). This was revised in April, 1975 and approved in August, 1976 with a total cost of Tk. 90·87 lakh (Foreign exchange component Tk. 61·22) for four years from 1974-75 to 1977-78. The expenditure incurred up to June, 1977 is Tk. 15·20 lakh. The allocated budget provision for 1977-78 is Tk. 9·00 lakh.

3.2. At the initial stage of the programme, when there was no fund, no office, no manpower and no equipment or materials, the scheme was running at the support of the participating organisations. Bangladesh Atomic Energy Commission provided manpower, office space and all other allied facilities. Forest Department also provided manpower, materials etc. The support received from other organisations like Ministry of Planning, Science and Technology Division, Water Development Board, Plant Protection Department, Survey of Bangladesh, Fisheries Department, Geological Survey, etc., are worth mentioning.

3.3. Bangladesh Embassy in Washington has throughout the period given constant support to the programme. Mr. S. R. Karim, Economic Minister, Bangladesh Embassy, Washington has jointly signed the agreement with NASA, along with Principal Investigator for receiving ERTS imageries from NASA. All correspondence with NASA and EROS Data Centre is communicated through him. He is actively persuing correspondances with NASA and other agencies in USA.

4. INTERNATIONAL COLLABORATION

4.1. UNDP is providing external assistance for this scheme with FAO as the executing agency. The initial commitment of UNDP for US $ 220,000 has been increased to US $ 469,150. An approixmate amount of $ 100,000 has been spent by UNDP/FAO for the schemes up to June 1977 in the form of equipments, materials, short term consultancy, seminar participation etc. The major part of UNDP contribution is likely to be spent during this year and next year.

4.2. NASA of USA has supplied LANDSAT Data to Bangladesh Landsat Programme free of charge through EROS Data Centre since 1973. So far US $10,000 have been spent by NASA for Bangladesh imageries. A request for another $ 20,000 for Landsat imageries has been made to NASA. This amount may be deposited in the Bangladesh account with the EROS Data Centre and the Landsat imegeries will be ordered from there.

4.3. International Development Research Centre (IDRC) has awarded Bangladesh a grant of $ 1,31,900 for special studies using Landsat imageries and ground truth observations. Dr. D. G. Protz of University of Guelph, Canada visited Bangladesh in 1977 and prepared a comprehensive plan for the studies of the watershed areas in Chittagong Hill Tracts to find the rate of siltation in the Karnafuli hydro-electric reservoir and also surface water and ecological study in the west and south west Bangladesh. This programme is likely to start in full swing from February, 1978.

4.4. IBRD is likely to support a programme for preparation of degitised colour land use map of Bangladesh using Landsat imageries. A project for a grant of US $ 2,25,000 has been sent to IBRD through ERD and is now under correspondence.

4.5. A package programme for training of LANDSAT Task Force members was prepared in 1976 and sent to USAID through ERD. This US $ 170,000 package is now under consideration and if approved will provide different level training to the investigators.

4.6. With all these international collaboration Bangladesh ERTS (LANDSAT) Programme is likely to develop its full capability in the use of Satellite Remote Sensing Technology which is a new scientific tool for resource development.

4.7. **International Commitments**:

4.7.1. ESCAP inter-governmental meeting on Remote Sensing and Satellite Surveying of the Economic and Social Commission for Asia and the Pacific (ESCAP) was held at Bangkok from 7-13, June 1977. The meeting was participated by 134 delegates from fifteen ESCAP member countries and six international organisations. Dr. Anwar Hossain, Principal Investigator, Bangladesh ERTS (LANDSAT) Programme and Chairman, Bangladesh Atomic Energy Commission was the leader of a five-member delegation from Bangladesh. He was elected as Chairman of the Technical and Drafting Committee of the meeting.

4.7.2. The meeting discussed latest development in the ESCAP countries in the field of Remote Sensing and Satellite Surveying. The concept of regionalisation of country facilities, research and development activities in the field of Remote Sensing and Satellite Surveying and Training Programmes and proposals in the field were discussed.

4.7.3. Bangladesh's favourable geographic position for a regional ground receiving station has been strongly projected in the meeting. Bangladesh also offered to host a regional centre for Remote Sensing and Satellite Surveying for the ESCAP Countries in Dacca. In the field of regional training programme, Bangladesh offered to extend the scope of the training workshop in Remote Sensing to be held in Dacca in December, 1978 to ESCAP to sponsor the same for regional participation.

4.7.4. Bangladesh's proposal for the research and development in the field of flood forecasting and water resources management, and coastal zone monitoring using Satellite Remote Sensing Technology was adopted in the meeting.

4.7.5. The meeting also discussed and adopted Bangladesh's proposal for the strengthening of activities of the ESCAP Secretariat to ensure progressive sharing of experience and knowledge in the field of Remote Sensing and Satellite Surveying in the region.

4.8. Twelfth International Symposium on Remote Sensing and Satellite Surveying

Environmental Research Institute of Michigan (ERIM) organises International Remote Sensing Symposium once every 18 months. Since the Eleventh Symposium, it has been decided that to make this symposium international in all respect, including the organisational aspect, every alternate symposium will be held outside Michigan. Accordingly ERIM sent out offer to different interested organisations in different countries including Bangladesh ERTS (LANDSAT) Programme in late 1976. Since Bangladesh ERTS (LANDSAT) Programme was then not equipped to host such a big international events, it was not possible for the programme to become the host. Philipines offered their willingness to host and Manila was selected for the venue of the XII Symposium to be held in April, 1978. The XIII Symposium will be held in Ann Arbor, Michigan in October, 1979. Bangladesh is now developing her capabilities and it is expected that she may be able to host the XIV Symposium to be held in early 1980. Principal Investigator, Bangladesh ERTS (LANDSAT) Programme has been included in the Organising Committee for the Manila Symposium and he may propose to the Organising Committee Bangladesh's desire to host the symposium at Dacca in early 1981.

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5. INDICATIVE FUTURE PROGRAMME OF ACTIVITIES

5.1. Introduction:

Bangladesh Earth Resources Technology Satellite (ERTS) now called Landsat Programme will be an essential supporting programme for the preparation of long term perspective plan for Bangladesh for its natural resources development in different economic sectors of the country. The main user sectors are Agriculture, Forestry, Water Resources, Cartography, Fisheries and Oceanography, Instrumentation, Geology and Meteorology. This programme aims at the development of capabilities to use space and remote sensing technology for inventorying natural resources and monitoring the natural hazards like cyclones, floods, storm surges, etc. in the country. The overall objectives of the various sectors of the ERTS Programme is summarised below:—

5.2. Agriculture Sector:

(1) To study the Land types and soil Characteristics.

(2) To study the cropping intensity and cropping pattern.

(3) To resolve and develop indentification keys for major crops, *e.g.*, rice, jute, sugarcane, wheat, potatoes.

(4) To determine the cultivated area for each species of rice, jute, sugarcane and other crops under multiple cropping pattern.

(5) To determine refined crops calendars for various important crops in different of the country.

(6) To estimate yields and production of major crops.

(7) To locate and estimate the extent of crop damage by natural phenomena such as flood, draught, disease, pests and weeds so that remedial measures can be taken.

5.3. Forestry Sector :

(1) To estimate the present and future forest production of the Sundarbans.

(2) To identify the changes in the coastal belt for natural afforestation purposes.

5.4. Water Resources Sector :

(1) Mapping of inundated areas and sand deposits on cultivable land.

(2) Studies of salinity distribution.

(3) Dry season surface water inventory.

5.5. Cartography Sector :

(1) The cartography programme in Bangladesh is designed to prepare up-to-date topographic maps of the country with the help of ERTS imagery. In addition, various types of thematic maps of the whole of Bangladesh will be produced as a co-ordinated programme of other individual units of Bangladesh ERTS programme.

5.6. Oceanography and Fisheries Sector :

(1) To determine the effectiveness and reliability of ERTS data significant to fisheries, both inland and marine waters.

(2) To determine the feasibility of using remote sensing data in locating the schools of fish and prawn in inland and marine water.

(3) To find out the usefulness of the remotely collected environmental, ecological and resource data for improving the harvest and management of important commercial species of fish and prawn.

5.7. Instrumentation Sector :

(1) Screening, selection, reproduction, storage and retrieval of ERTS data received from NASA.

(2) Operation, maintenance, repair and calibration of instruments used in Bangladesh ERTS Programme.

(3) To store the standard spectral signatures of our important crops such as different varieties of rice, jute, sugarcane, potato, tea, tobacco forest types and also free water surface and water depths to be prepared from study of the reflectance characteristics by individual sectors.

(4) To process and reproduce remotely sensed data by both manual and computer methods in collaboration with other sectors.

(5) Timely distribution of ERTS data to individual users.

5.8. Geology Sector :

(1) To identify gross lithological/formational division.

(2) To delineate broad structures in the northern and eastern parts of the country.

(3) To study the changes in the river channels in selected areas.

(4) To identify and classify drainage patterns.

5.9. Meteorology and Atmospheric Research Sector :

(1) To investigate the utilisation of satellite imagery for meteorological observation with the objective of augmenting existing cyclone studies.

(2) To study cloud dynamics using satellite imagery.

(3) To forecast crops using meteorological and satellite data.

(4) To eliminate atmospheric effects on ERTS data.

5.10. In addition to the above sectoral activities, the following specific projects will be undertaken jointly by the Task Force members in collaboration with other national and international agencies :

(1) A colour land use map of Bangladesh to be prepared by using computer Compatible Tapes (CCT).

(2) Study of Karnafully reservior and its watershed in Chittagong Hill-Tracts.

(3) Study of surface water in the lower Ganges Basin for development of dry season water resource for irrigation and land use.

(4) Study of the saiinity intrusion in the southern and Western parts of Bangladesh.

(5) Preparation of a crop inventory of specific test sites in Bangladesh.

(6) Preparation of maps showing cropping pattern and intensity in the coastal belt.

(7) Study of the land accretion phenomenon in the Bay of Bengal.

(8) Study of causes of floods & assessment of damages.

(9) Formulation of Regional Programme for water resource managements and Flood studies.

(10) Monitoring of coastal zone and inland river courses and exploration of marine and fish resource of the country.

(11) Co-ordination with aerial photography project.

(12) Development of photo-interpretation laboratory including colour photo labs.

6. FUTURE PROJECTIONS.

6.1. To accomplish the future activities, it is pre-requisite that LANDSAT imageries are available in the country continuously. It will, however, be difficult to get LANDSAT imageries continuously from NASA due to limitation of Tape Recorder capacity in the satellites. Moreover, NASA will primarily rely on direct transmission in future satellites. As such, a satellite ground station is required in Bangladesh urgently. The main purpose of this ground station will be to receive data from both resource satellites and meteorological satellites. The real time data that will be received from the ground station will be used in monitoring the country's economic activities specially in the agriculture and water resources sectors. The resource satellite data when combined with more synoptic meteorological satellite data, also received through the ground station on real time basis, will also help in improving the National Storm Warning Service. The scope of this satellite ground station may be extended in future for advanced satellite systems like LANDSAT-D, Seasat, Heat capacity mapping Mission (HCMM), Metsat (TIROS-N and Geostationary), etc., introduced by NASA/NOAA of USA and such organisations of other countries.

6.2. With these points in view, a scheme has been prepared by the Bangladesh LANDSAT Programme with a total estimated cost of Tk. 17 crore (F.E.C. Tk.12 crores). This scheme is an expansion of the Bangladesh ERTS (LANDSAT) survey programme which is an approved on going programme. This expanded programme envisages setting up of a National Remote Sensing Centre that will be equipped with dual purpose ground receiving station and attached laboratory facilities for processing and distribution of satellite data. In this expanded scheme of the Bangladesh ERTS (LANDSAT) programme the approved scheme for the expansion of the Space and Atmospheric Research Centre (SARC) of Bangladesh Atomic Energy Commission has been integrated. The combined scheme is scheduled to start from July, 1978. To operate these expanded programme as truly independent scientific activity, it has been proposed in the scheme to set up an organization known as Space Research and Remote Sensing organisation (SPARRSO) which will be an autonomous body to run the Space Research and Remote Sensing activities in the country. The organizational structure of SPARRSO is shown in Appendix III. In the first meeting of the reconstituted National ERTS Committee held on 12-10-1977, this scheme has been recommended for approval. Earlier Bangladesh Atomic Energy Commission has offered space for establishment of SPARRSO in its Savar complex site. Science Adviser to the President has also examined the scheme and the details in the scheme have been incorporated as per his suggestions. The scheme is now awaiting formal approval by the Government.

6.3. With the satellite receiving station and ancillary facilities installed under this arrangement and with trained manpower available under the programme, Bangladesh will be in a position to host a Regional Centre for Remote Sensing and Satellite Surveying at Dacca. The proposed Regional Centre can be developed into a research-*cum*-training centre for satellite remote sensing investigations in the region. Bangladesh has also a great geographical advantage in claiming for such a regional remote sensing centre. It is virtually at the centre of a large number of ESCAP countries. A

standard ground station located at Dacca will cover all these countries, partly or fully and will offer the highest number of country coverage as compared to any other country of the region. With financial assurances available through the scheme "Bangladesh ERTS (LANDSAT) programme phase II" for establishment of ground station and ancillary facilities for International Standard Remote Sensing Centre in the Country, Bangladesh may offer to ESCAP its facilities for establishing a Regional Remote Sensing Centre at Dacca. Since the concept of regional centre for Remote Sensing and satellite surveying is now under review in ESCAP an early implementation of the 'Bangladesh ERTS(LANDSAT) Programme Phase-II is most desirable.

6.4. Bangladesh is a young country, but determined to develop its scientific and technological potential for the exploitation of her natural resources for the welfare of her people. The proposed SPARRSO will provide facilities to obtain real time data from satellites that will be useful to achive this national aspiration. With regionalization of SPARRSO facilities, Bangladesh will offer to the countries of the south and South-East Asian region real time satellite data of their country for the purpose of inventorying their natural resources and monitoring the natural hazards. Establishment of SPARRSO will thus be a major first step in developing Bangladesh's national capability in offering scientific and technical co-operation to the neighbouring countries of the ESCAP region. SPARRSO will thus become a symbol of Bangladesh's scientific and technological advancement.

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25. **A television talk on "Remote Sensing"** *by* Dr. ANWAR HOSSAIN on 18th January, 1975.
26. **A television talk on satellite surveying** *by* M. U. CHOUDHURY on 18th January, 1975.
27. **A Radio talk on "application of Remote Sensing in Agriculture"** *by* Dr. A. M. CHOWDHURY, on 15th January, 1975.
28. **Photo interpretation in Geology** *by* HASSAN FARUQUE, January 1975.
29. **Place of Aerial Photograph and ERTS imagery in Bangladesh Soil Survey** *by* M. R. RAHMAN, January, 1975.
30. **Aerial photo interpretation and coastal morphology** *by* Professor M. I. CHOUDHURY, January, 1975.

31. **Some notes on ERTS—National Programme for ERTS—Symposium in Dacca** *by* F. Z. KUTENA, January 1975.

32. **ERTS imagery utilisation in Bangladesh** *by* M. U. CHOUDHURY, January 1975.

33. **Application of Remote Sensing in Agriculture in Bangladesh** *by* Dr. ANWARUL AZIM and QUAZI TAFAZZAL HUSSAIN, January 1975.

34. **ERTS applications on Hydrology** *by* SYED MOHIUDDIN MANSUR, January, 1975.

35. **Fisheries resources of Bangladesh and application of Remote Sensing to Fisheries** *by* MAHMMED AHSANULLAH, January, 1975.

36. **Ramote Sensing with ERTS applied to Water Resources in Bangladesh** *by* MUSTAFIZUR RAHMAN TARAFDAR, January, 1975.

37. **Aerospace reconnaissance and photogrammetry** *by* Wing Commender A. K. M. MATIUR RAHMAN, January, 1975.

38. **Photogrammetry and its utility** *by* NOOR MUHAMMED MIAN, January, 1975.

39. **Introductory note on photogrammetry** *by* SALAHUDDIN AHMED, January, 1975.

40. **Photo Interpretation for Forestry in Bangladesh** *by* M. U. CHOUDHURY, January, 1975.

41. **Uses of Satellite Photo and its future in Bangladesh** *by* M. H. KHAN CHOUDHURY, January, 1975.

42. **Remote Sensing over tropical storms and its possibilities in Bangladesh** *by* MIR. FAKHRUL QUAYUM, January, 1975.

43. **Television and remote pick up** *by* KHALED SALAHUDDIN AHMED, January, 1975.

44. **Introduction of satellite communication in Bangladesh for international telecommunication** *by* A. K. M. TAHER, January, 1975.

45. **Remote Sensing in wildlife management in Bangladesh** *by* M. U. CHOUDHURY, Presented at the First National Wildlife Seminar held in the Department of Zoology, Dacca University on January, 29-30, 1975.

46. **Interview report in 'Bichitra' on Remote Sensing and Satellite Survey** *by* DR. ANWAR HOSSAIN.

47. **Interview report in 'Bichitra' on Remote Sensing and ERTS** *by* M. U. CHOUDHURY.

48. **Mosaic map of Bangladesh from ERTS, (LANDSAT-I) imageries showing project areas of studies in the fields of agriculture, forestry, water resources, cartographyl oceanography, an and fisheries**—A. M. CHOUDHURY, M. A. H. PRAMANIK, M. M. RAHMAN and M. A. JALIL, Weekly Bichitra", Dacca, 21 February, 1975. III Yr. No. 38, Back cover page.

49. **A number of ERTS-I photographs reproduced** *by* THE INTERPRETATION TECHNIQUES SECTORS were supplied to Bichitra which was published on 21st March 1975.

50. **A special ERTS news Bulletin,** February 22, 1975.

51. **A small scale mosaic map of Bangladesh prepared from ERTS (LANDSAT-I) Imageries.** February 1975—A. M. CHOUDHURY, M. A. H. PRAMANIK , M. M. RAHMAN and M. A. JALIL.

52. **Technique of development on printing of photographic black and white Film (APT/ERTS).** March 1975—M. A. H. PRAMANIK and M. A. JALIL.

53. **Cyclone warning with space technology** *by* A. M. CHOWDHURY, March 1975—Presented at the Bangladesh Civil Defence Study Course held at the Atomic Energy Centre on March 7, 1975.

54. **Report on the preparatory Mission (February-March, 1975) of** DR. ANWAR HOSSAIN, *Principal Investigator, ERTS Programme.*

55. **ERTS-B (LANDSAT-2) 18-day global coverage calendar, 1975** *by* M. A. H. PRAMANIK, April, 1975.

56. **Report on attendence of UN Inter-Governmental Seminar on Remote Sensing Canada, NASA Earth Resources Survey Symposium, Houston and WMO Congress, Geneva** *by* DR. A. M. CHOUDHURY, 1975.

57. **Photo-interpretation Lecture note** *by* M. U. CHOUDHURY, 1975.

58. **Study of land formation in Bangladesh with Landsat imageries**—DR. ANWAR HOSSAIN & M.U. CHOUDHURY. Presented at the international Symposium on Remote Sensing of enviroment held at Ann Arbor, Michigan, USA, October 1975.

59. **"Reclamation of land from the sea in Bangladesh"** *by* M.R. TARAFDAR. Presented at Seminar on "Flood Control and allied problems in Bangladesh held in October 1975 jointly sponsored *by* B.W. D.B. and the NATHERLAND TECHNICAL ASSISTANCE PROGRAMME.

60. **Utilisation on Remote Sensing Technology in Natural Resources Development in Bangladesh**—ANWAR HOSSAIN & M.U. CHOUDHURY. Presented, at the International symposium on remote sensing of enviroment held at Ann Arbor, Michigan, USA, in Oct. 1975.

61. **ERTS-B (LANDSAT) 18-day global coverage calendar 1975. December, 1976** *by* M.A.H PRAMANIK.

62. **Land formation in the coastal belt of Bangladesh its expectation (in Bengali)** *by* M. U. CHOUDHURY. Presented at the 1st Bangladesh Conference on Mangrove afforestation at Barisal. January, 1976.

63. **Land formation in the coastal belt of Bangladesh—Its ecology and development strategy** *by* M.U. CHOUDHURY. Paper presented at the 2nd National Geographical Conference at Rajshahi in Feb. 25—29, 1976.

64. **Remote Sensing in Geography** *by* A. M. CHOWDHURY. Presented at the 2nd annual geography conference held at Rajshahi, February 25—29, 1976.

65. **Use of ERTS imageries in Geography** *by* M.A.H. PRAMANIK. Presented at the 2nd annual geography conference held at Rajshahi, February 25—29, 1976.

66. **Study of the Haor of Sylhet-Mymensingh districts with ERTS imageries (Winter Crop Estimation).** Presented at the First Annual Bangladesh Science Conference held at Dacca, March 28—31, 1976.

67. **Mangrove Afforestation in Bangladesh** *by* M. U. CHOUDHURY. First National Science Conference, 1976.

68. **A model of coastal land accretion** *by* A. M. CHOUDHURY. Presented at the Annual Bangladesh Science Conference held at Dacca, March 28—31, 1976.

69. **An analysis of the setellite pictures of the cyclones in the Bay of Bengal from 1968 to 74**—A. M. CHOUDHURY, M.K. ANAM and M.A. JABBAR. Presented at the First Annual Bangladesh Science Conference, Dacca, March 28—31, 1976.

70. **Remote Sensing in Agriculture**—DR. A. AZIM. Presented in a seminar in the department of Plant Protection in June 1976.

71. **A study of the Haor areas of Sylhet-Mymensingh districts with ERTS mageries** (Winter Crop Estimation)—Mr. A.M. CHOUDHURY, Dr. A. AZIM, S. AHMED and S. RAHMAN. March 1976.

72. **Mosaic maps of Bangladesh in Band 4, 5, 6 & 7** *by* M.U. CHOUDHURY, R. KAJAL, SALAUDDIN AHMED & N.H. MACLEOD.

73. **Joint report on attendance of short course/Symposium on remote sensing and technical visits** discussion in USA, August 1976—DR. ANWAR HOSSAIN AND M.A.H. PRAMANIK.

74. **Index to Landsat coverages of Bangladesh, September 1976**—M.A.H. PRAMANIK AND M.J. KABIR.

75. **Some problems in Geologic interpretation with LANDSAT imaging** *by* M. ABU BAKAR. Seminar talk, 16th September 1975.

76. **An ERTS map of coastal afforestation programme** *by* M.U. CHOUDHURY

77. **Remote Sensing activities in Bangladesh. A paper presented** *by* Dr. A.M. CHOUDURY in the UN/IAF Workshop held in Anaheim, California, USA from Sept. 26 to Oct. 9, 1976.

78. **Bangladesh LANDSAT Programme—A review of the programme and a report on the result of investigation** *by* Dr. ANWAR HOSSAIN AND Mr. M. U. CHOUDHURY. Presented at the discussion session at Goddard Space Flight Centre NASA, October 18—20, 1976.

79. **Land From the Bay** *by* Dr. A.M. CHOUDURY—Published in the Bangladesh Times on October 4, 1976.

80. **A Satellite for the Millions** *by* Dr. A.M. CHOUDHURY—Published in the Bangladesh Times on October 12, 1976.

81. **Human Ecology and Development.** And address to the inaugural session of the Fourth Commonwealth Conference of Human Ecology and Development, Dacca December 13, 1976 *by* Dr. ANWAR HOSSAIN.

82. **Human Ecology case studies in Bangladesh** *by* M.U. CHOUDHURY—Fourth Commonwealth Conference on Human Ecology and Development, Dacca, December 13—18, 1976.

83. **Landsat (ERTS) activities in Bangladesh**—M.A.H. PRAMANIK. Presented at the UN Regional Training Seminar of Remote Sensing applications held in Karachi (Pakistan), January 17-18, 1977.

84. **Studies on National Resources through Remote Sensing Technology in Bangladesh**—Q.T. HOSSAIN. Presented at UN Regional Training Seminar on Remote Sensing Applications held in Karachi (Pakistan), January 17-18, 1977.

85. **Report on the participation in the UN Regional Seminar on Remote Sensing applications** held in Karachi, January 17-18, 1977—M.A.H. PRAMANIK.

86. **Case studies: Bangladesh Environment**—M U. CHOUDHURY. Presented at the 1st Bangladesh National Conference of Forestry held in Dacca from February 11—15, 1977.

87. **Resource, data collections with satellite**—A.M. CHOUDHURY. Presented at the First National Statistical Conference held in Dacca from 7—9 March, 1977.

88. **A Mosaic Map of Coastal Area of Bangladesh** in Band 6, March, 1977.

89. **Earth Resources Technology Satellite (ERTS) Programme**—A. HOSSAIN, M. U. CHOUDHURY, M.A.H. PRAMANIK AND N. H. MACLEOD. Published in the Bulletin of the Bangladesh Physical Society "THE PHYSICIST" Vol. I, March 1977, pp. 10—14.

90. **Remote Sensing and Satellite Surveying in Bangladesh,** a slide lecture in the Asiatic Society of Bangladesh *by* M. U. CHOUDHURY, 1977.

91. **Land Utilisation and Ecological aspects in the Sylhet-Mymensingh Haor region,** (an analysis of Landsat data)—PROF. M. I. CHOUDHURY and K. MOUDOOD ELAHI. Presented at the 11th international Symposium on Remote Sensing of Environment held at Environmental Research Institute of Michigan, USA, April 1977.

92. **A combined ground station for both resource and meteorological satellites**—M. A. H. PRAMANIK, M. K. ANAM. Presented at the Brain Storm Session of Bangladesh Atomic Engery Commission, May, 1977.

93. **Forestry support for Agriculture in Bangladesh** *by* M. U. CHOUDHURY, 1977.

94. **Space programme for Bangladesh**—A. M. CHOUDHURY, presented at the Brain Storm Session of B. A. E. C. held in May, 1977.

95. **Remote sensing and satellite surveying** (a background paper on the latest position of the status of Remote Sensing and Satellite surveying in Bangladesh)—DR. ANWAR HOSSAIN. Presented at the ESCAP Inter governmental meeting on Remote Sensing and Satellite surveying held in Bangkok. June, 1977.

96. **Investigations using data from LANDSAT-2**—Dr. ANWAR HOSSAIN. Published in Weekly Government Abstracts NTISUB, USA. July 11, 1977.

97. Investigation using data from LANDSAT-2—ANWAR HOSSAIN. Published in Weekly Government Abstracts NTISUB, USA. June 27, 1977.

98. **Studies on Cropping system and cropping intensity with the help of Remote Sensing Technology**—DR. A. AZIM, Q. T. HOSSAIN, S. U. AHMED & F. U. BHUYIAN, presented in the cropping system and intensity meeting held at Bangladesh Agriculture Research Council (BARC). August, 1977.

99. **Project—Proposal for Space Research and Remote Sensing Organisation (SPARRSO)**—A. HOSSAIN, M. U. CHOUDHURY M. A. H. PRAMANIK, AND M. J. KABIR. August, 1977.

100. **Scheme for Bangladesh ERTS (LANDSAT) Programme** Phase II—A. HOSSAIN, M. U. CHOUDHURY M. A. H. PRAMANIK, AND M. J. KABIR. September, 1977.

101. **Activities of Bangladesh ERTS (LANDSAT) Programme (March 1974—August 1977)**—A. HOSSAIN, M. U. CHOUDHURY M. A. H. PRAMANIK, AND M. J. KABIR. September, 1977.

102. **Preliminary studies of Sedimentation pattern and Land formations in the Feni and Little Feni river studies** by using ERTS (LANDSAT) imageries—N. H. MACLEOD AND M. A. H. PRAMANIK October, 1977.

103. **Scope for remote Sensing of Geological features in Bangladesh, Jour Asiatic Soc., Bangladesh,** *by* M. A. BAKR.

104. **Quarternary Geomorphic evolution of the Brahmanbaria Noakhali area, Comilla and Noakhali districts Bangladesh** Records, Geol. Surv. Bangladesh, Vol. I, part 2 *by* M. A. BARAK.

Note.—Papers from Serial No. 20 to 24 and 28 to 44 were presented at the First Bangladesh National Seminar on 'Remote Sensing' held in Dacca, Jan. 16—20,1975.

LIST OF FIGURES

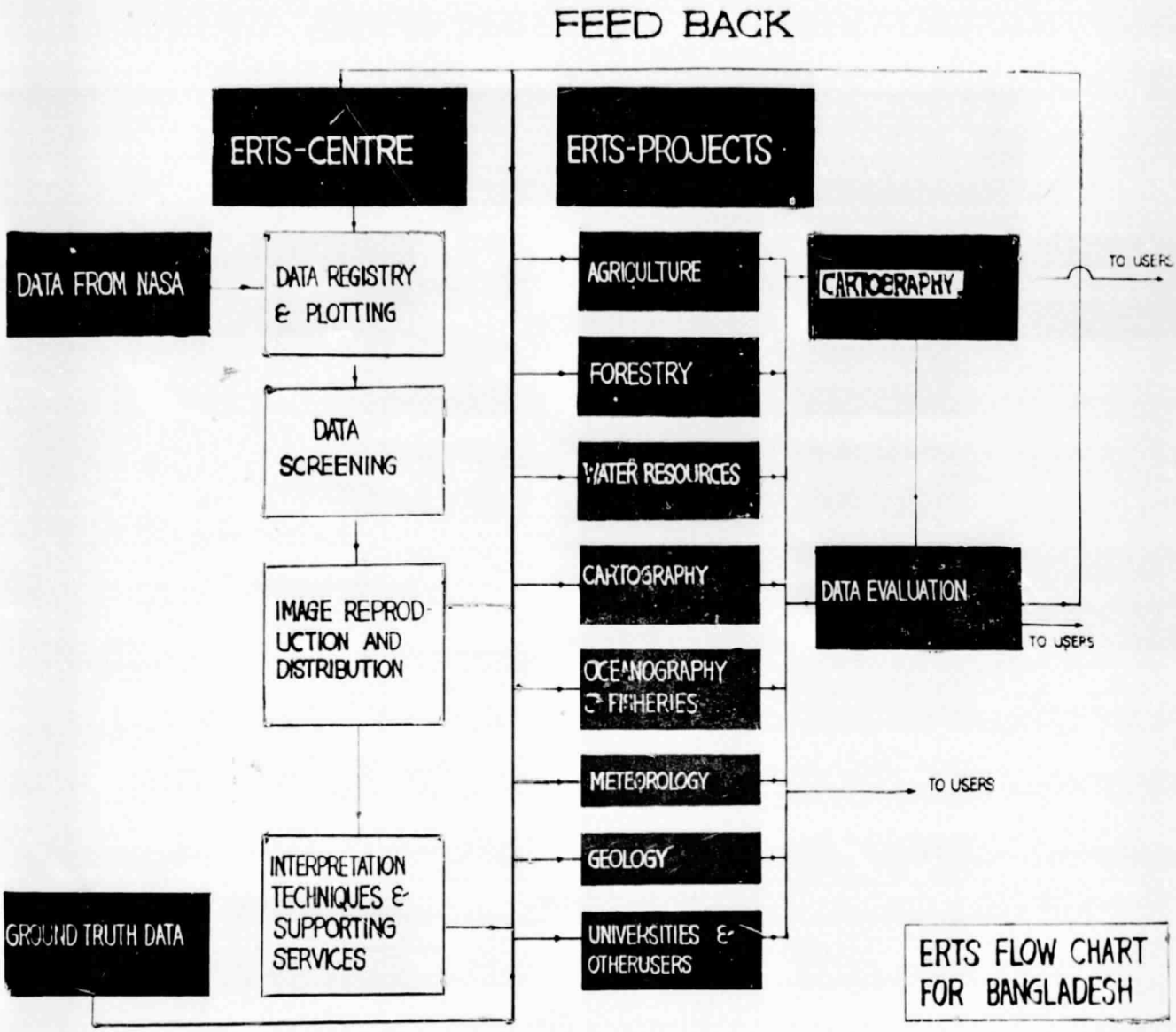

Fig.1. Flow chart of Bangladesh ERTS(LANDSAT) Programme.

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ERTS IMAGE FORMATS IN BANGLADESH

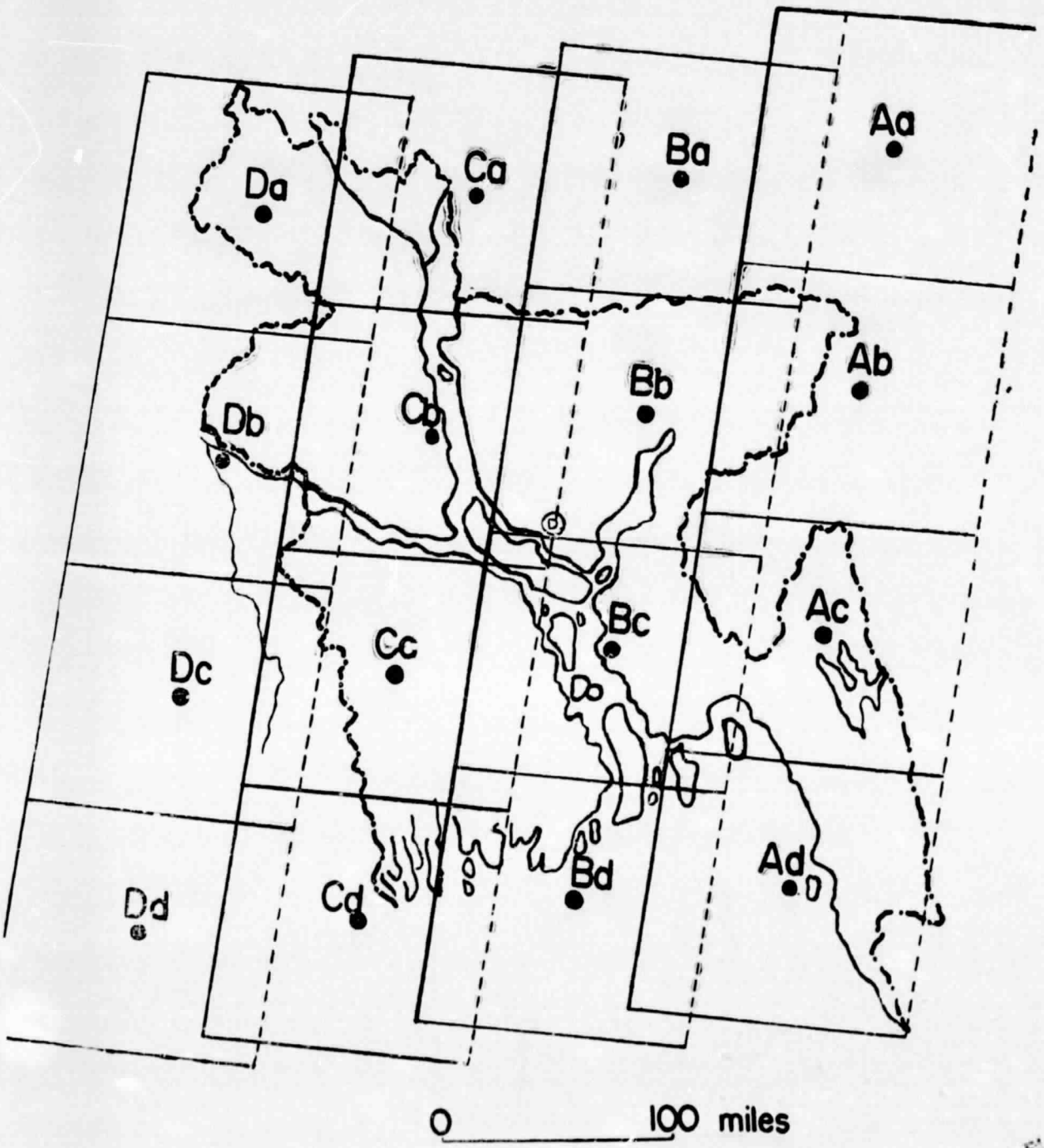

Fig.2. 16 ERTS image for mats of Bangladesh.

Fig. 3: Land-use map of Noakhali and Chittagong coastal area, (original scale 1 : 200,000, colour)

Fig. 4: First ERTS Mosaic of Bangladesh (Original scale 1 : 1,000,000 Black and White)

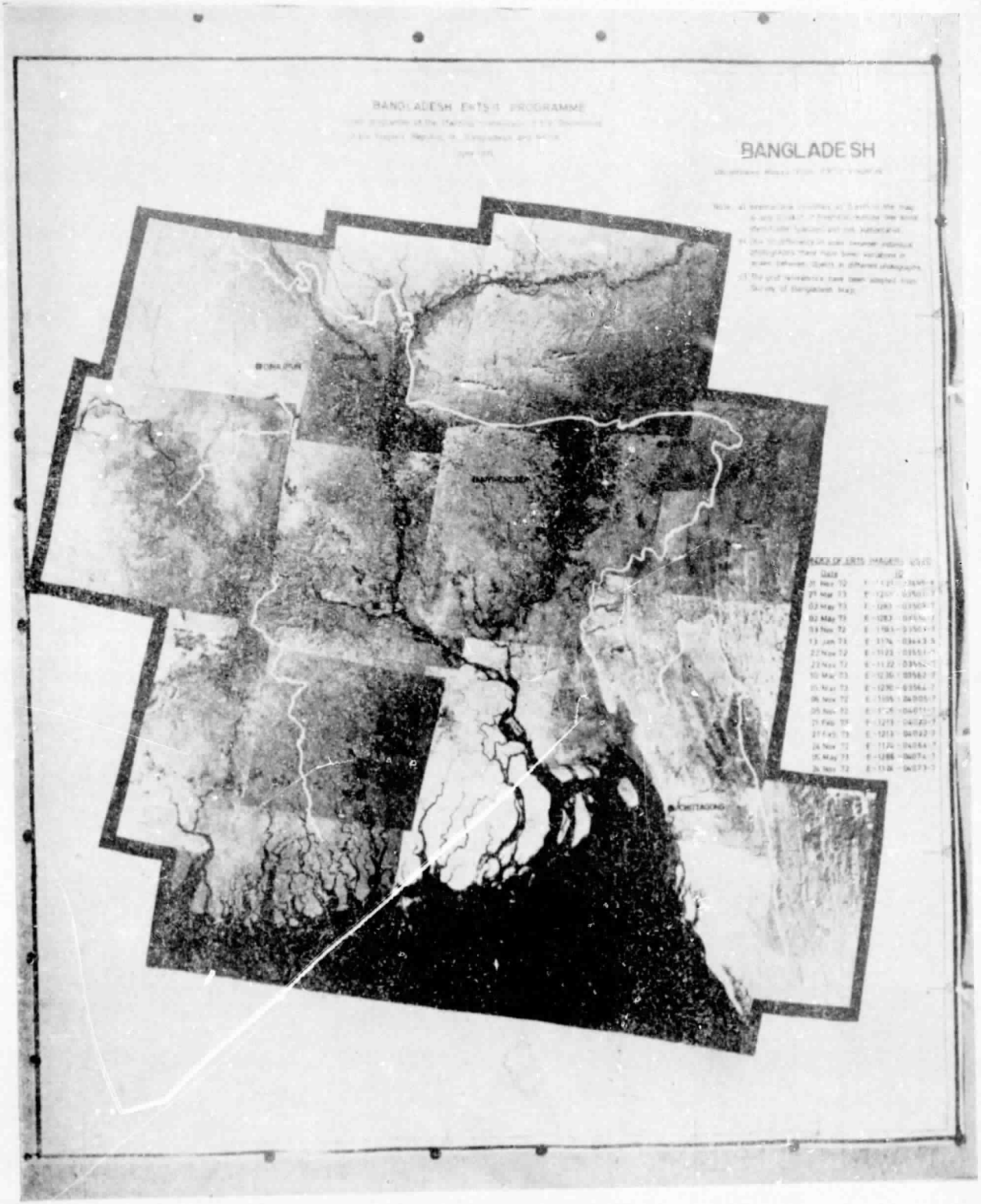

Fig. 5: A sample mosaic map of Bangladesh prepared from ERTS imageries. (original scale 1:1,000,000, Black & White)

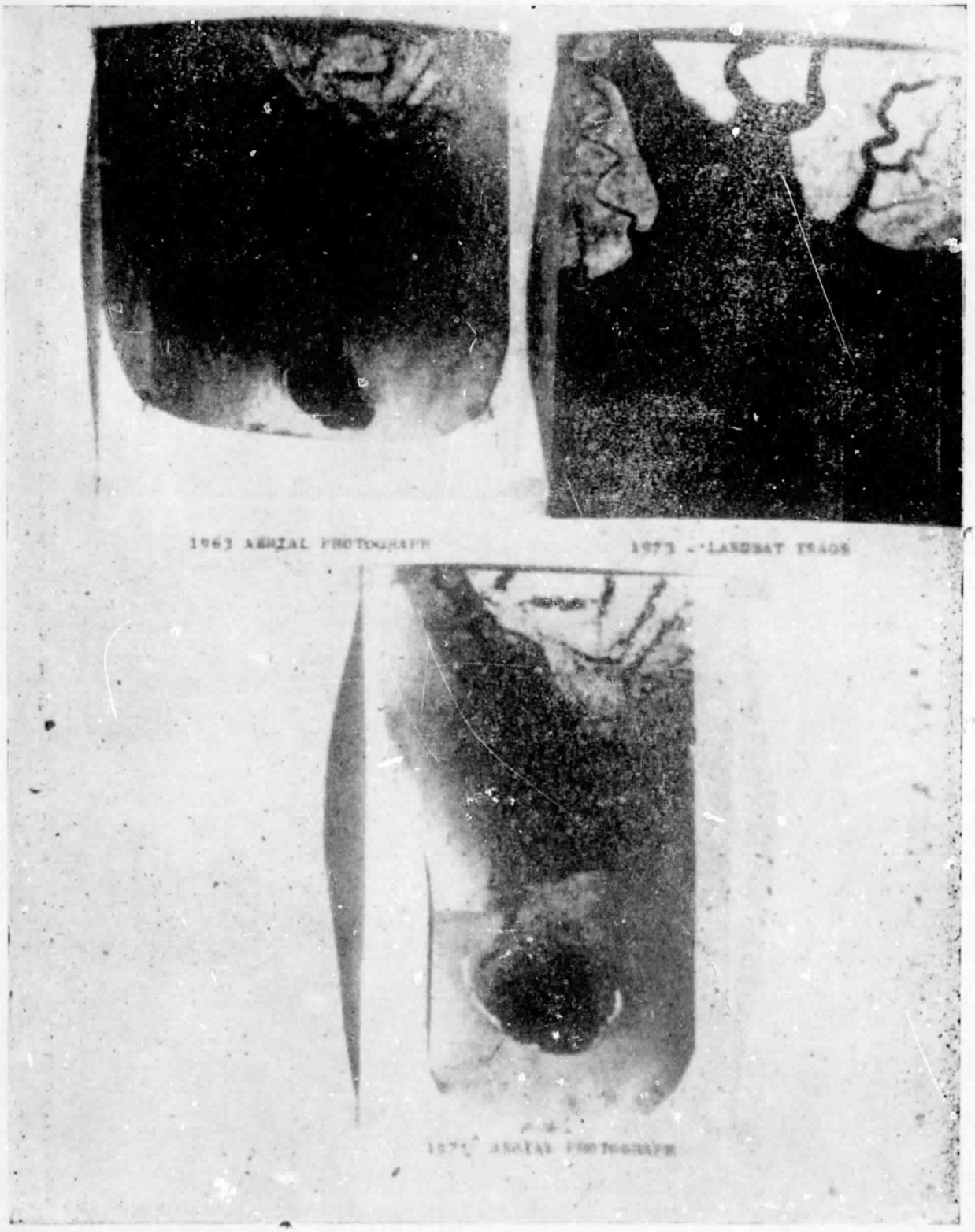

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Fig. 7 : ERTS map used for Bangladesh Coastal Afforestation Programme (original scale 1 : 1,000,000, Black & White)

Fig. 8 : Mosaic map of Bangladesh coast in band 4 used for delineation of base line, (original scale 1 : 1,000,000, Black & White).

Fig. 9 : Land-use map of Sylhet-Mymensingh Haor area (original scale 1 : 50,000, colour)

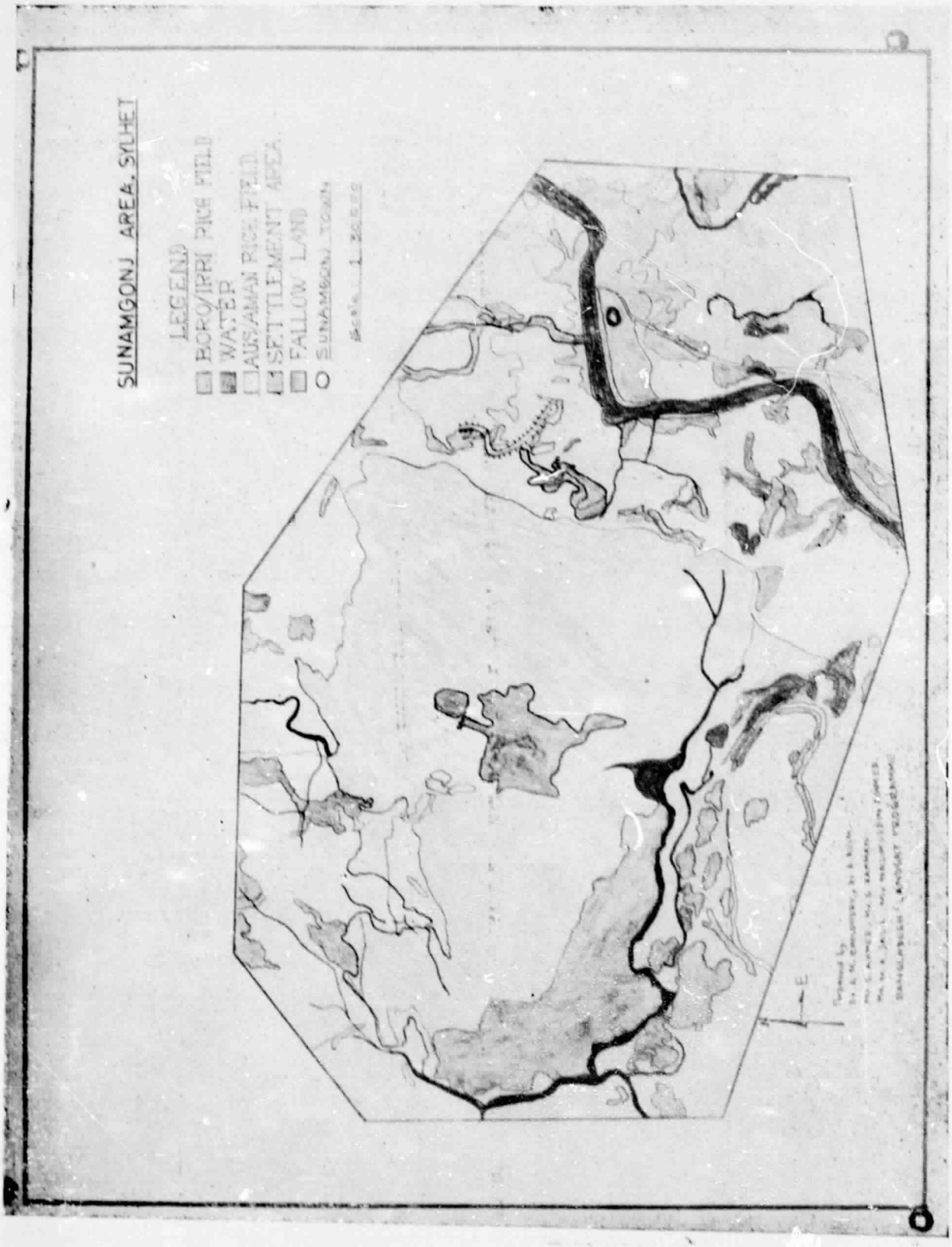

Fig. 10 : Land-use map of Sunamgonj area (original scale 1 : 30,000, colour)

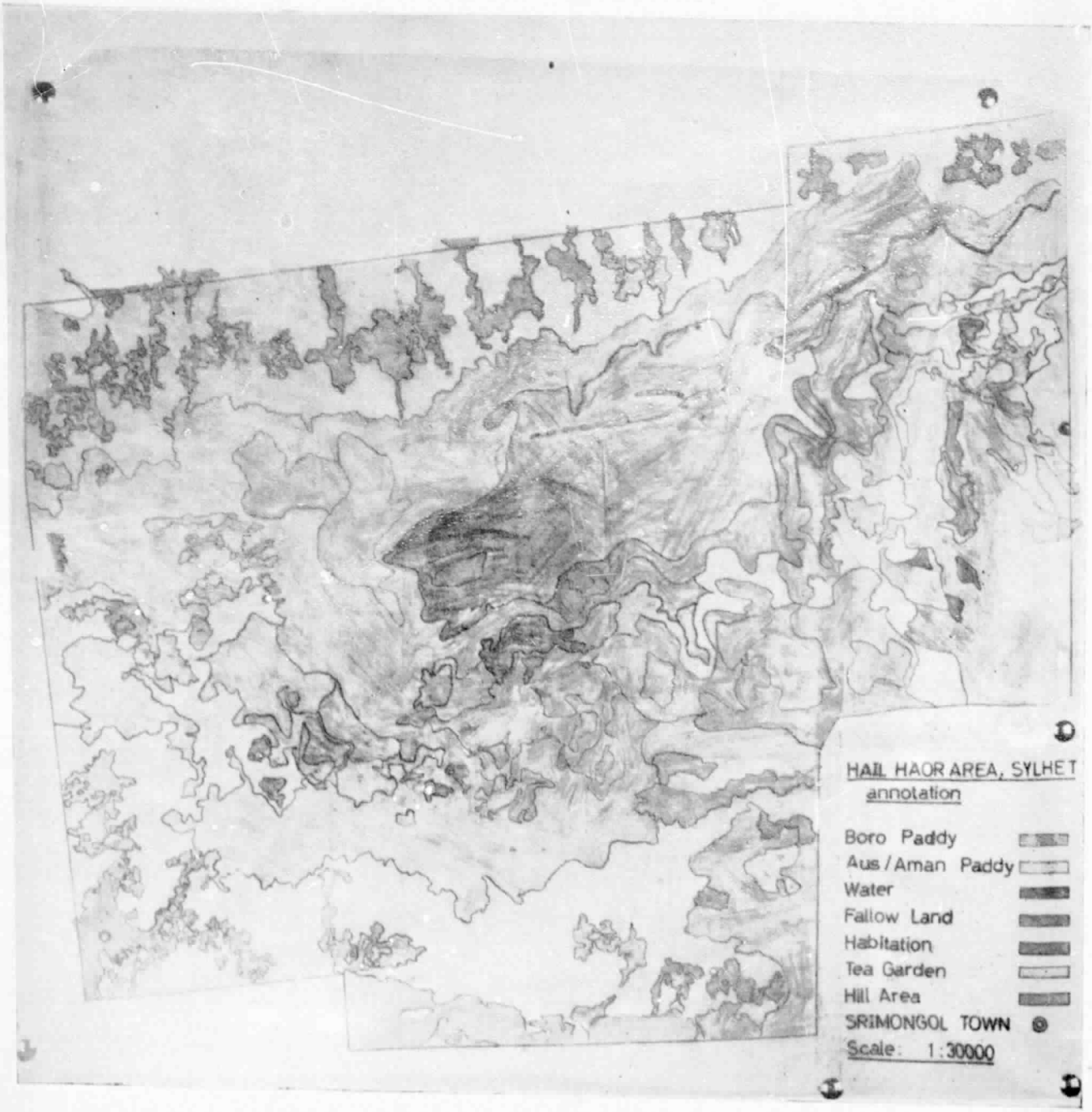

Fig. 11 : Land-use map of Hail Haor (Srimangol) area (original scale 1 : 30,000, colour)

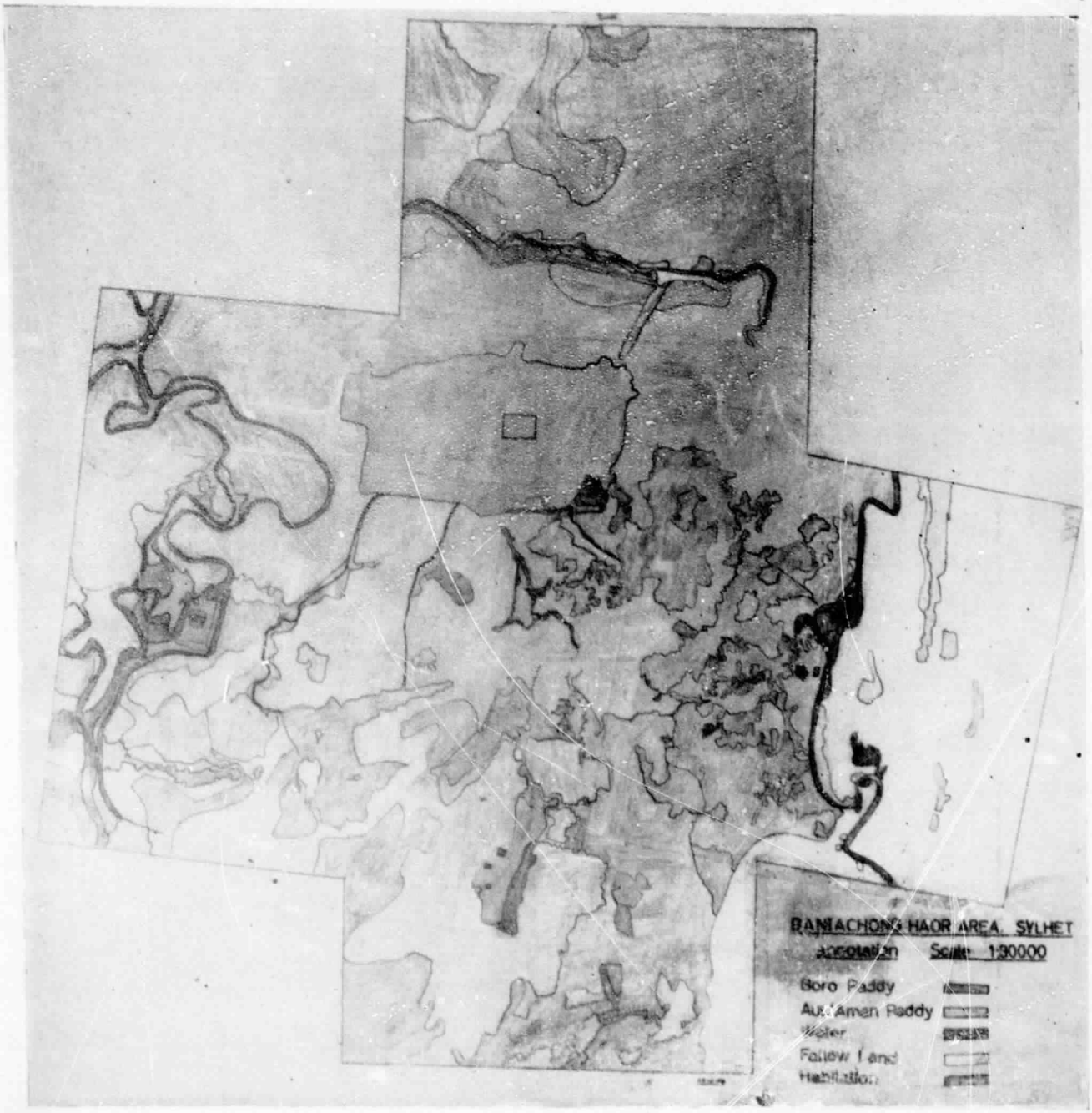

Fig. 12 : Land-use map of Baniachong Haor area (original scale 1 : 30,000, colour)

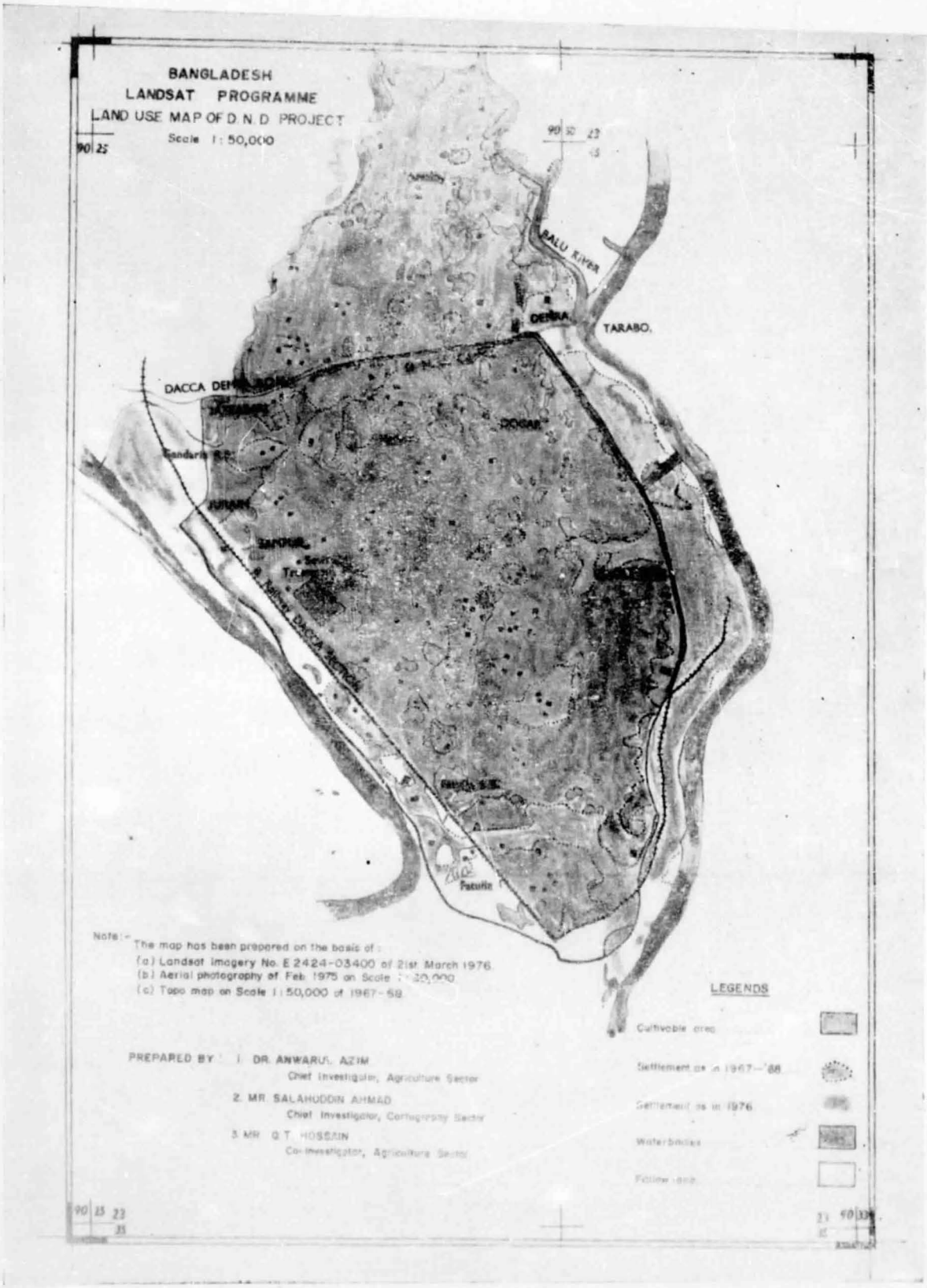

Fig. 13 : Land-use map of Dacca-Narányanangj-Demra Project areas (original scale 1 : 50,000, colour)

Fig. 14 : Mosaic map showing Bangladesh-Burma-India Border. (original scale 1 : 1,000,000 Black & White)

Fig.—15 : Satellite (LANDSAT—1) imagery showing the geomorphic units in the Brahmanbaria–Noakhali area lying between the Meghna River and the Tripura Hills. imagery No. 1176–03553, Band 5, Jan, 1973 (Courtesy NASA and Bangladesh ERTS Programme).

Landsat ground receiving station coverages in ESCAP region

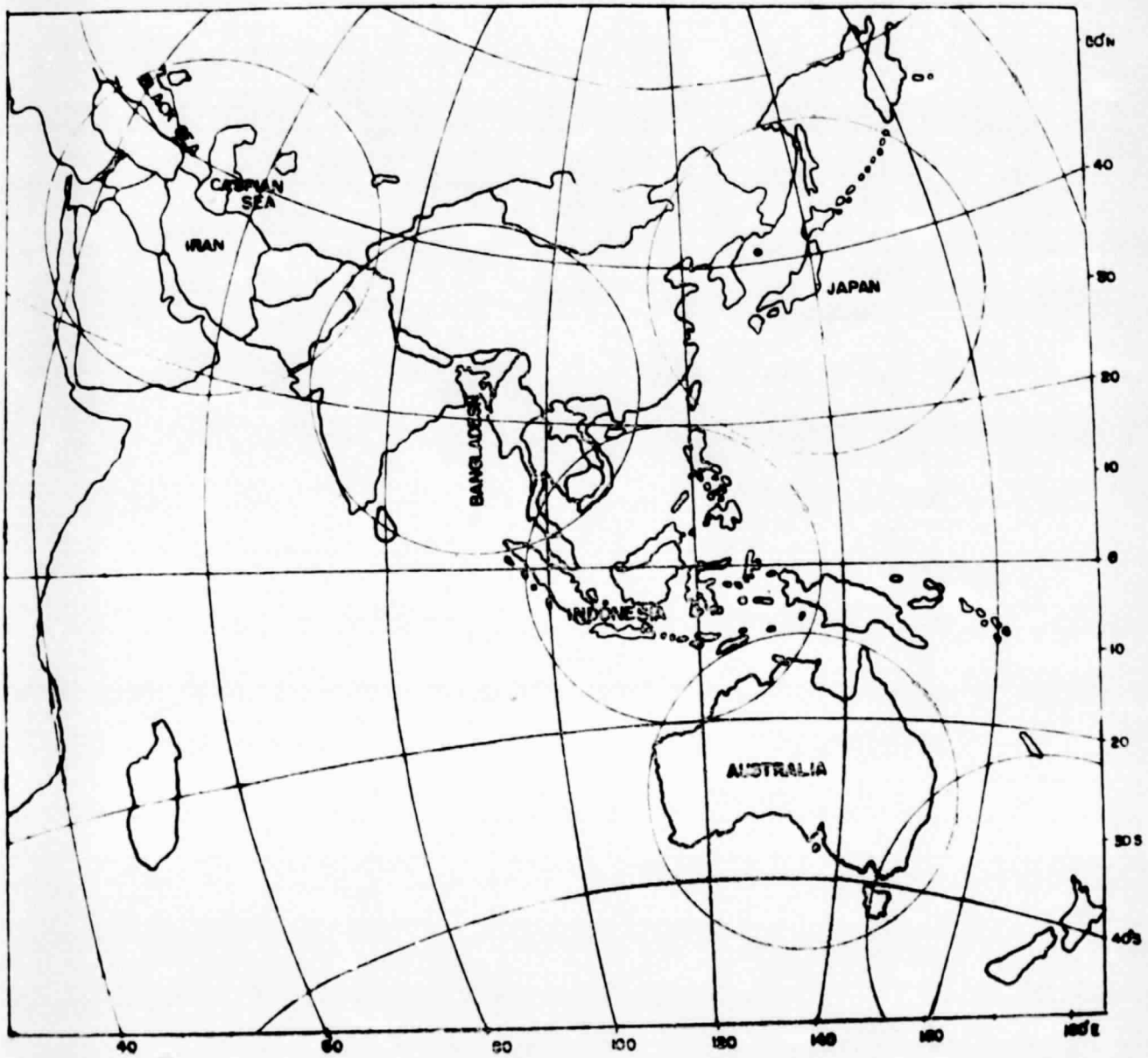

Fig. 16 : LANDSAT ground receiving station coverages.

Appendix:-I

NASA Earth Resources Survey Program

NTIS
National Technical Information Service

Weekly Government Abstracts

Technical report summaries for science, technology, business, and federal, state, and local governments

June 27 1977

NTISUB/C/093-026

NTIS
National Technical Information Service

Weekly Government Abstracts

Technical report summaries for science technology, business, and federal, state, and local governments

July 11 1977

NTISUB/C/093-028

Notice to WGA subscribers No newsletter issued for issue 77-27 due to lack of input.

REPORTS CONTAINING AUTHOR-IDENTIFIED SIGNIFICANT RESULTS

Investigations using Data from LANDSAT-2.
Anwar Hossain,

Atomic Energy Commission, Dacca (Bangladesh), Feb. 77, 5p NASA-CR-152632

E77-10138 Price code: PC A02/MF A01

The author has identified the following significant results. New lands for forestation were set aside in the coastal area of Bangladesh, based on LANDSAT mosaics (Chittagong) -195,000 acres, Noakhali- 450,000 acres, Barisal - 360,000 acres and Patuakhali - 225,000 acres). LANDSAT imageries were used for identification of drainage patterns in both the old and new Comilla district.

Investigations using Data from LANDSAT-2.
Anwar Hossain.

Atomic Energy Commission, Dacca (Bangladesh), Apr. 77, 4p NASA-CR-152698

E77-10152 Price code: PC A02/MF A01

The author has identified the following significant results.

LANDSAT imageries of Mirpur area of Dacca district were used in connection with surveys for black plastic clay. The imageries showed the broad pattern of small valleys cutting into Madhupur clay. Land-use maps of Haor areas of Sylhet and Mymensingh districts were prepared. As a test case, two thana areas, namely, Nickley and Astogram were classified in different categories such as crop, settlement, and water. It does not show much agreement with the Agriculture Dept's. statistics.

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APPENDIX II

ERTS TASK FORCE MEMBERS

Sl. No.	Name and Designation of Officers with Parent Office.	Sectors.	Responsibilities.
1.	DR. ANWAR HOSSAIN, *Chairman, Bangladesh Atomic Energy Commission.*	All	Principal Investigator, (Director-General).
2.	MR. M. U. CHAUDHURY, *Officer-in-charge (Planning) Forests, Fisheries and Livestock Div., Ministry of Agriculture.*	Forestry	Chief Investigator and Secretary, ERTS Task Force.
3.	MR. M. A. MUYED *Asstt. Chief Conservator of Forests, Office of the Chief Conservator of Forests.*	,,	Investigator.
4.	MR. M. ASHRAFUL ISLAM, *Extra Asstt. Conservator of Forests, Office of D.F.O., Cox's Bazar.*	,,	Co-Investigator.
5.	MR M. A. H. PRAMANIK, *Director (Instrumentation) SARC, BAEC.*	Instrumentation	Chief Investigator.
6.	MR. MOHD. JAHANGIR KABIR, *Scientific Officer, SARC, BAEC.*	,,	Investigator.
7.	MR. M. A. JALIL, *Junior Engineer, SARC, BAEC.*	,,	Co-Investigator.
8.	DR. A. AZIM, *Deputy Director, Deptt. of Plant Protection.*	Agriculture	Chief Investigator.
9.	MR. A. K. M. FARIDUDDIN BHUIYA, *Senior Scientific Officer, Agriculture Research Institute.*	,,	Investigator.
10.	MR. Q. T. HOSSAIN, *Asstt. Aerial Pest Control Officer, Deptt. of Plant Protection.*	,,	Co-Investigator.
11.	MR. M. A. RASHID, *Deputy Director, Bangladesgh Water Dev. Board.*	Water resource	Chief Investigator.
12.	MR. MONSOOR ALI, *Asstt. Engineer, Special Project Preparation Cell, BWDB.*	,,	Investigator.
13.	MR. M. A. GAFOOR *Asstt. Technical Officer, BWDB.*	,,	Co-Investigator.
14.	MR. M. ABU BAKR, *Superintending Geologist, Geological Survey of Bangladesh.*	Geology	Chief Investigator.
15.	MR. MIZANUR RAHMAN, *Asstt. Geologist, Geological Survey of Bangladesh.*	,,	Investigator.
16.	MR. MOHD. HASSAN, *Asstt. Geologist, Geological Survey of Bangladesh.*	,,	Co-Investigator.

Sl. No.	Name and Designation of Officers with Parent Office.	Sectors.	Responsibilities.
17.	DR. A. M. CHOUDHURY, *Director, SARC, BAEC.*	Meteorology	Chief Investigator.
18.	MR. M. A. JABBAR, *Senior Scientific Officer, SARC, BAEC.*	,,	Investigator.
19.		,,	Co-Investogator.
20.	MR. M. AHSANULLAH, *Senior Scientific Officer, Marine, Biological Lab., Cox's Bazar.*	Oceanography and Fisheries.	Chief Investigator.
21.	MR. LIAQUAT ALI, *Senior Scientific Officer, Fisheries Directorate.*	,,	Investigator.
22.	MR. SHAFIQUR RAHMAN, *Hydrologist, Fisheries Directorate.*	,,	Co-Investigator.
23.	MR. SALAHUDDIN AHMED, *Project Officer, Survey of Bangladesh.*	Cartography	Chief Investigator.
24.	..	,,	Investigator.
25.	..	,,	Co-Investigator.

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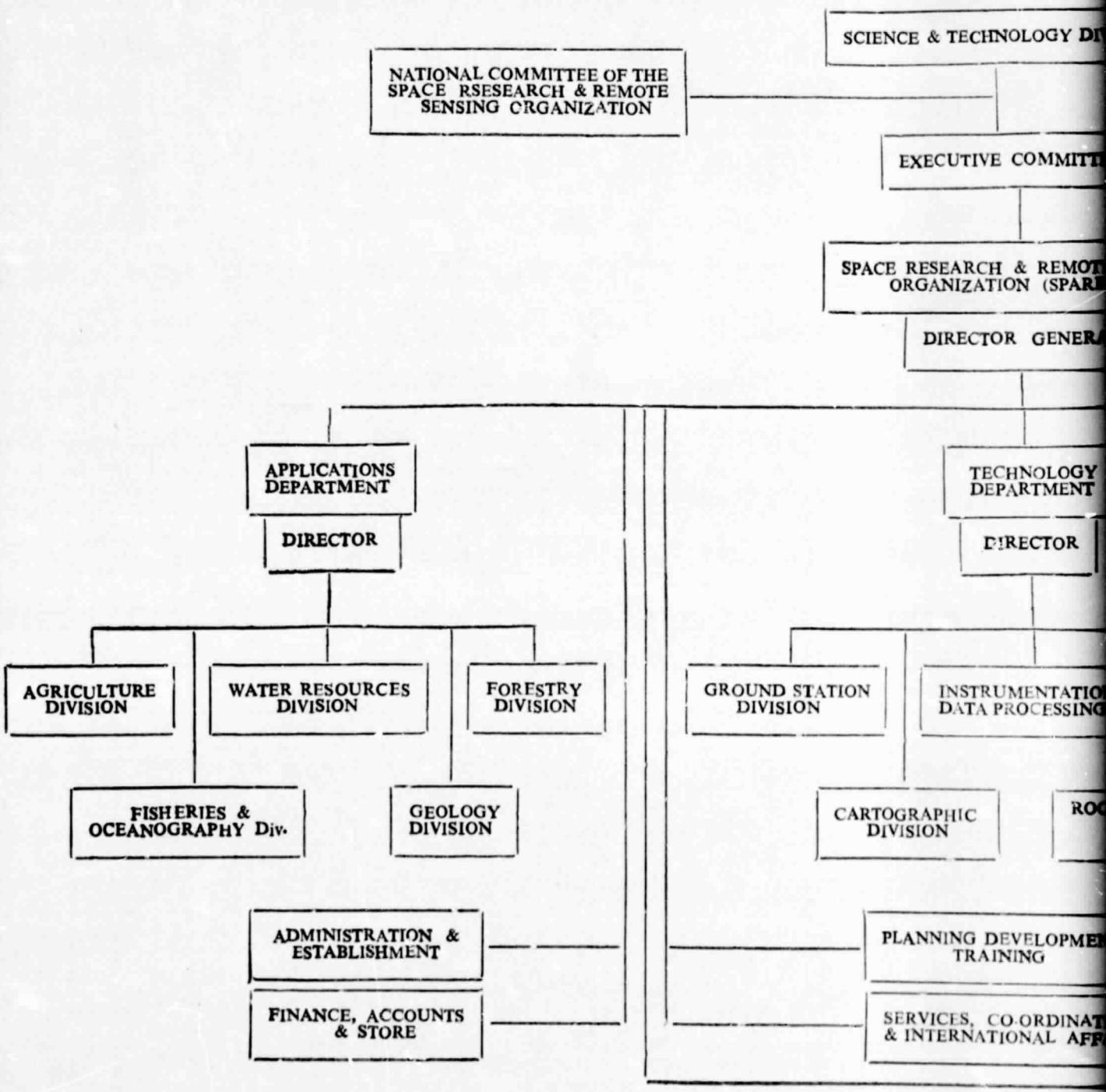
APPENDIX—III

ORGANIZATION STRUCTU



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