PART III TECHNICAL REPORT

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1. Survey Plan

1-1 Object

Map is one of the indispensable basic material for the planning of agricultural development projects. The purpose of the present project is to cover the proposed area by aerial photos at suitable scale, to prepare photomap with height information covering a part of the proposed area where the planning is urgently required, to clarify micro-topography of the area and then to obtain the relationship between topography and water. At the same time the states of vegetation and land-use are also surveyed to obtain their relationship to topography, which will help in investigating micro-topography of other part of the project area covered by vegetation or land-use in future.

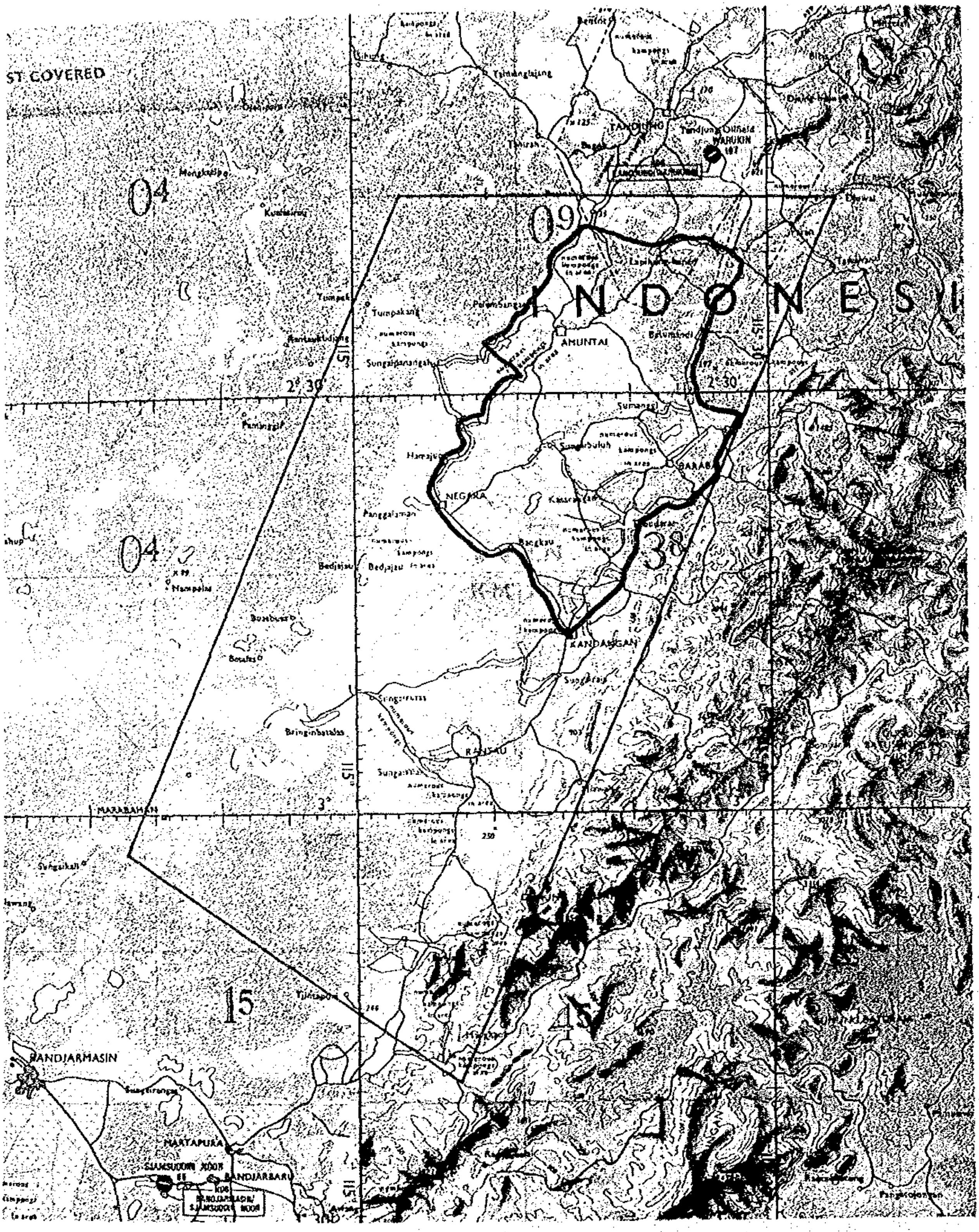
1-2 Scope of Work

The scope of work of the present project is included in a document agreed upon between DPU and JICA in April, 1983 [5],

"Scope of Work for the Topographic Mapping of the Negara River Basin in South Kalimantan in the Republic of Indonesia."

The outline is as follows and location of the project area is shown in Fig. 1.1.

(1) Black and white panchromatic aerial photography in the dry season at the scale of 1/20,000 covering the area of approximately 1,200km^2 in Amuntai region,



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Area covered by aerial photos in dry season (6,300km²)

Area covered by aerial photos in rainy season and photomaps (1,200km²)

Fig. 1.1 Location Map of Aerial Photography and Photomapping

(2) Black and white panchromatic aerial photography for getting information of land situation in the rainy season at the scale of 1/20,000 covering the area of approximately 1,200km^2 in Amuntai region,

(3) Topographic mapping in the form of 1/10,000 scale controlled mosaic photomap, which is produced based on the aerial photos taken in the dry season and represents the necessary land information of rainy season in the above area (for which a thematic map shall also be prepared on the basis of the photomap showing landform classification, vegetation distribution and land-use mode by photo-interpretation of aerial photos with field verification and supplementation),

(4) Black and white panchromatic aerial photography in the dry season covering the area of approximately 5,100km^2 in the region between Amuntai and Banjarmasin.

1-3 Overview of the Survey Area

1-3-1 Extent of the Survey Area

The survey area lies in the southern part of the Kalimantan Island and belongs to the South Kalimantan Province as administrative district.

Kalimantan Island lies nearly at the center of the Malay Archipelago and is the third biggest island of the world. The equator runs through the central part of the island. In topography, the northern and eastern parts of the survey area are mountainous and the southern and western parts are vast flat swampy areas formed by great rivers such as the Barito River or the Kapuas River.

The project area is swampy area in the Negara River basin adjacent to hilly area at the eastern edge. The Negara River flows down to the south from small rivers around Mt. Sarempaka and joins with the Barito River at Marabahan. In upland regions in the basin of these rivers, lie major cities like Tanjung, Amuntai, Barabai. The project area is included in the area of the "Topographic Mapping Project of the Barito River Basin, Republic of Indonesia" executed by the Overseas Technical Cooperation Agency (now JICA) in 1974. [1, 2] The 1/50,000 scale topographic maps prepared by the above project are available, which are important materials for the present project.

1-3-2 Topography and Geology

The western part of the photomapping area is flat area formed by mainly the Negara River and the eastern edge is low relief mountainous area. In the central part, extends deltaic plain formed by tributaries like the Batangalai River and the Barabai River and paddy fields are widely cultivated. In the western part, however, villages and paddy fields lie partly only on natural levee along the Negara River and almost of vast swamps remain unused. Geology forming the eastern mountainous area consists of sedimentary rocks such as sandstone and mudstone of the Mesozoic era and granite penetrating them. Thick laterite layer has developed on the surface of the eastern mountainous area and terrace of more or less 50m in height extending in the north-eastern part, due to heavy weathering peculiar to humid tropical environment. Supply of materials to the present rivers is limited to the above soil component of fine grain. It is considered that owing to the above phenomenon, river water in the project area runs always muddy in red.

1-3-3 Meteorology

Based on rainfall data observed in four cities in the survey area, annual rainfall graphs are drawn as shown in Fig. 1.2, where the left side of columnar graph (white column) of each month is of 1983 and the right side (hatched column) is the mean value between 1975 and 1984. (16-1)

From the above, monthly rainfall from June to October (dry season) is from 100mm to 150mm and, from November to May (rainy season), it exceeds generally 200mm. Especially, it is from November to February that monthly rainfall becomes maximum and it records more than 300mm almost every year.

Annual water level change is shown in Fig. 1.3 based on the records of water gauges installed in Amuntai along the Negara River and in Sungai Buluh along the Batangalai River, one of the tributaries of the Negara River. The records were taken in 1983, from which it is seen that the difference between the highest and lowest water levels is about 4m in Amuntai and about 1m in Sungai Buluh. Water level change looks like having a tendency that in both regions water level reaches highest in rainy season (during November and March), goes down once in April, continues low level from May to July and again goes up a little. It should be added that as far as judging from the annual rainfall graph shown in Fig. 1.2, in the observed year of 1983, the rainfall had a tendency of smaller amount than that of the mean rainfall of 10 years.

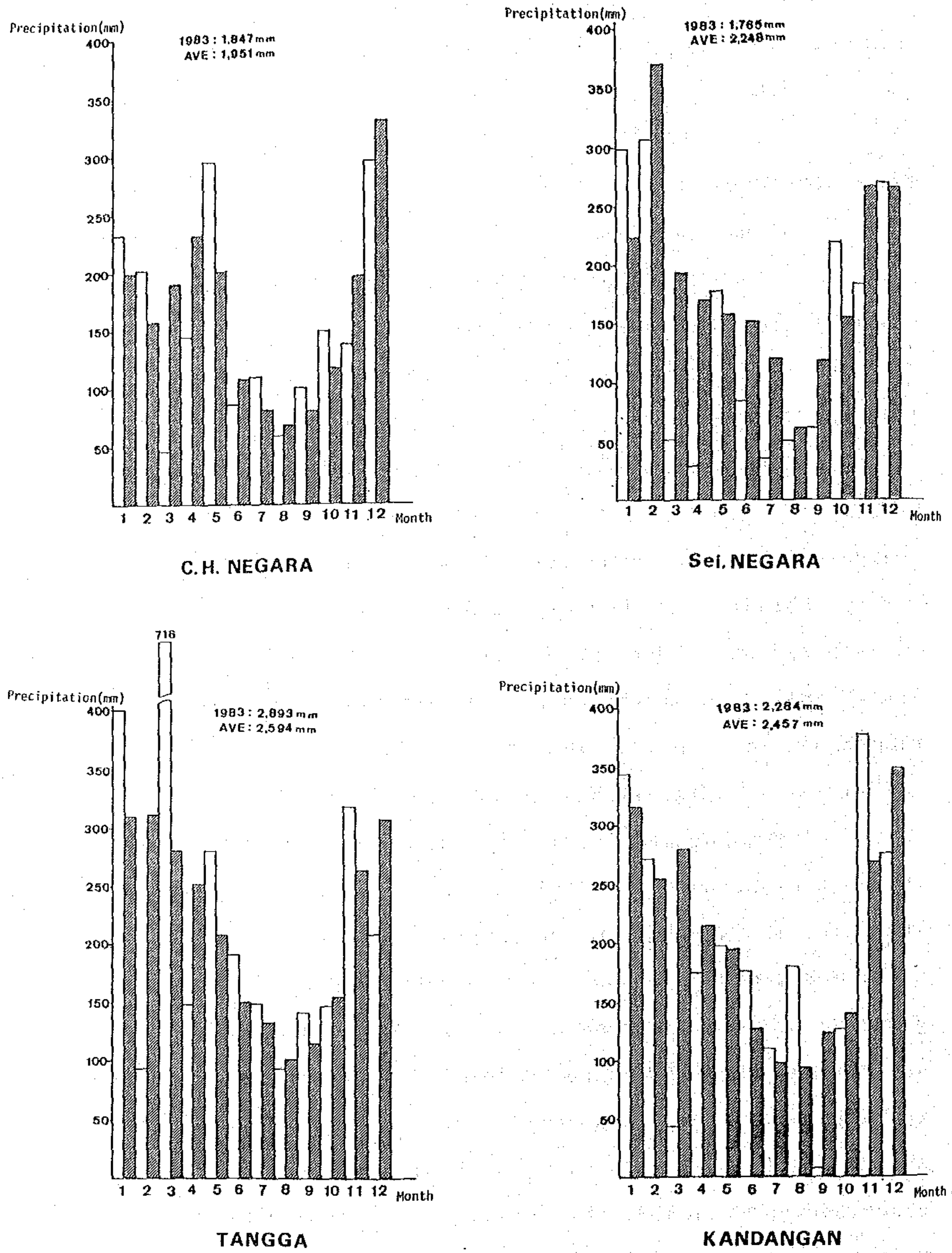
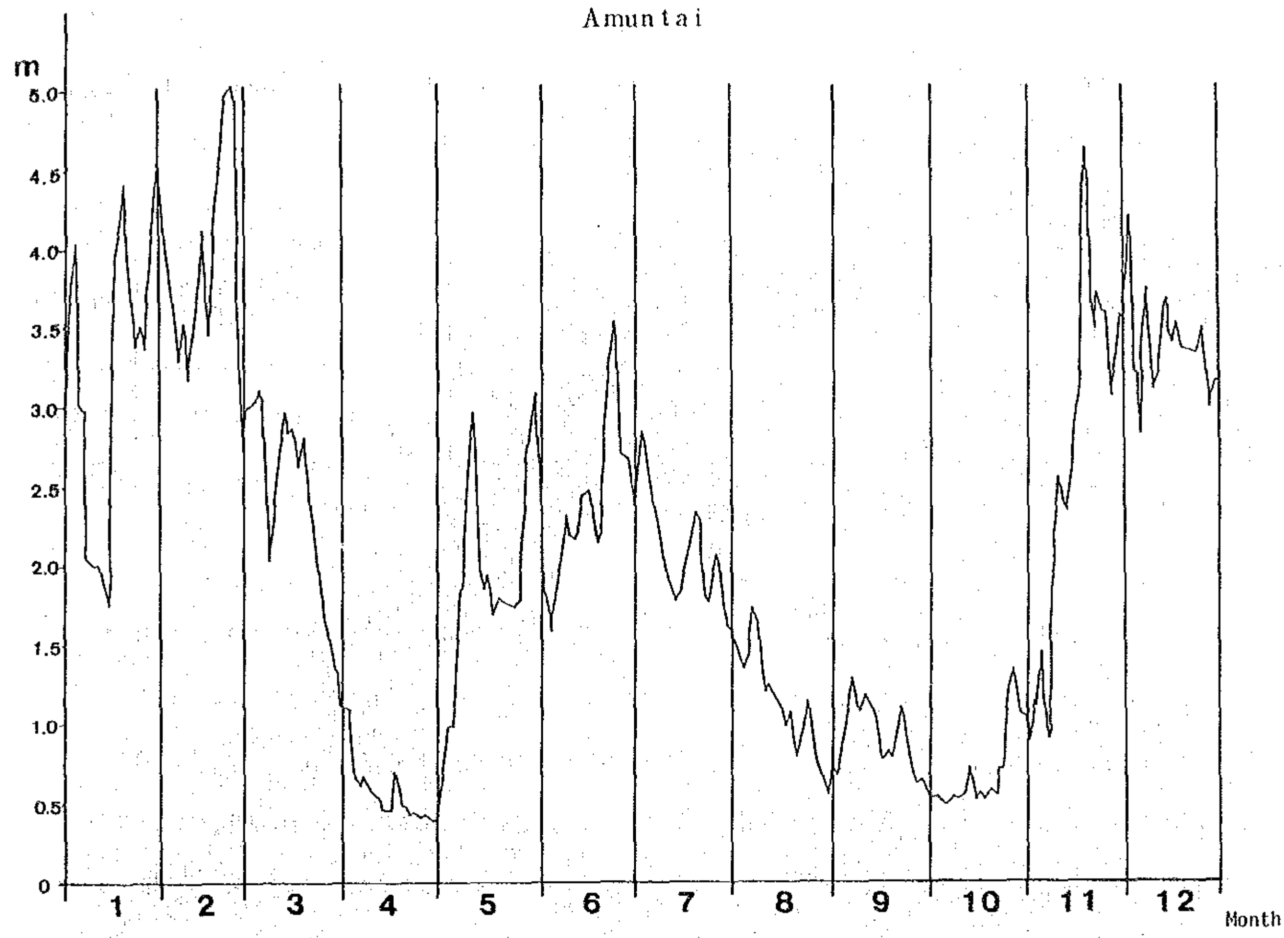


Fig. 1.2 Monthly Precipitation in the Survey Area



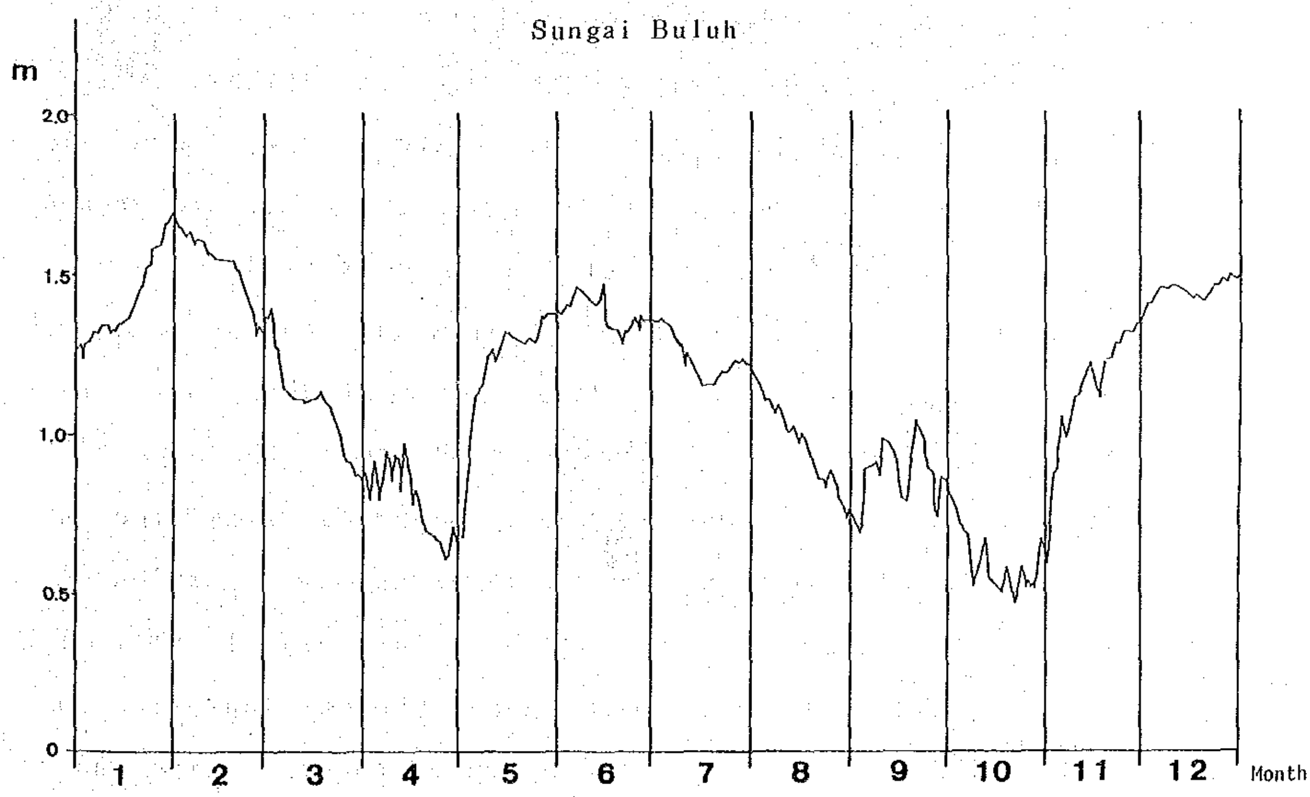


Fig. 1.3 Water Level Change (based on daily mean)

1-3-4 Land-use

The outlook of land-use in the survey area is shown in Fig. 1.4 and its areal ratio is given in Tab. 1.1.

Land category	Housing land	Paddy field, etc.	Pasture	Wilderness	Forest	Water surface	Total
Areal ratio (%)	1.5	44.4	5.0	19.4	27.8	1.9	100

Tab. 1.1 Areal Ratio of Land-use

Land-use in the survey area corresponds well to topography: cultivated land mainly of paddy field spreads in deltaic area of relatively high altitude and hausing lands, forming principal cities of Amuntai, Barabai, Kandangan and Negara, lie in deltaic area of relatively high altitude, the areal ratio being very small (1.5%). Most of them are situated on natural levee. Paddy field spreads over deltaic area as its center and occupies 44% of the total area. Most of them are rain-fed or of gravity (flow) irrigation cultivated in rainy or dry season. Pastures spread over widely in swampy area along the Negara River and buffaloes are grazed. Wilderness occupies 19.4% of the total area and spreads mainly over swamp. Forest occupies 27.8% of the total area, consisting of rubber plantations, palm trees and natural forests. Rubber plantations are distributed on deltas and hilly areas in the northern part of the survey area. Most of them are poorly managed. Palm trees are planted around housing land on natural levee and are distributed all over the survey area. On the area of relatively slightly high elevation like natural levee, housing land, banana plantation in and around it and palm trees protruding them, together with paddy

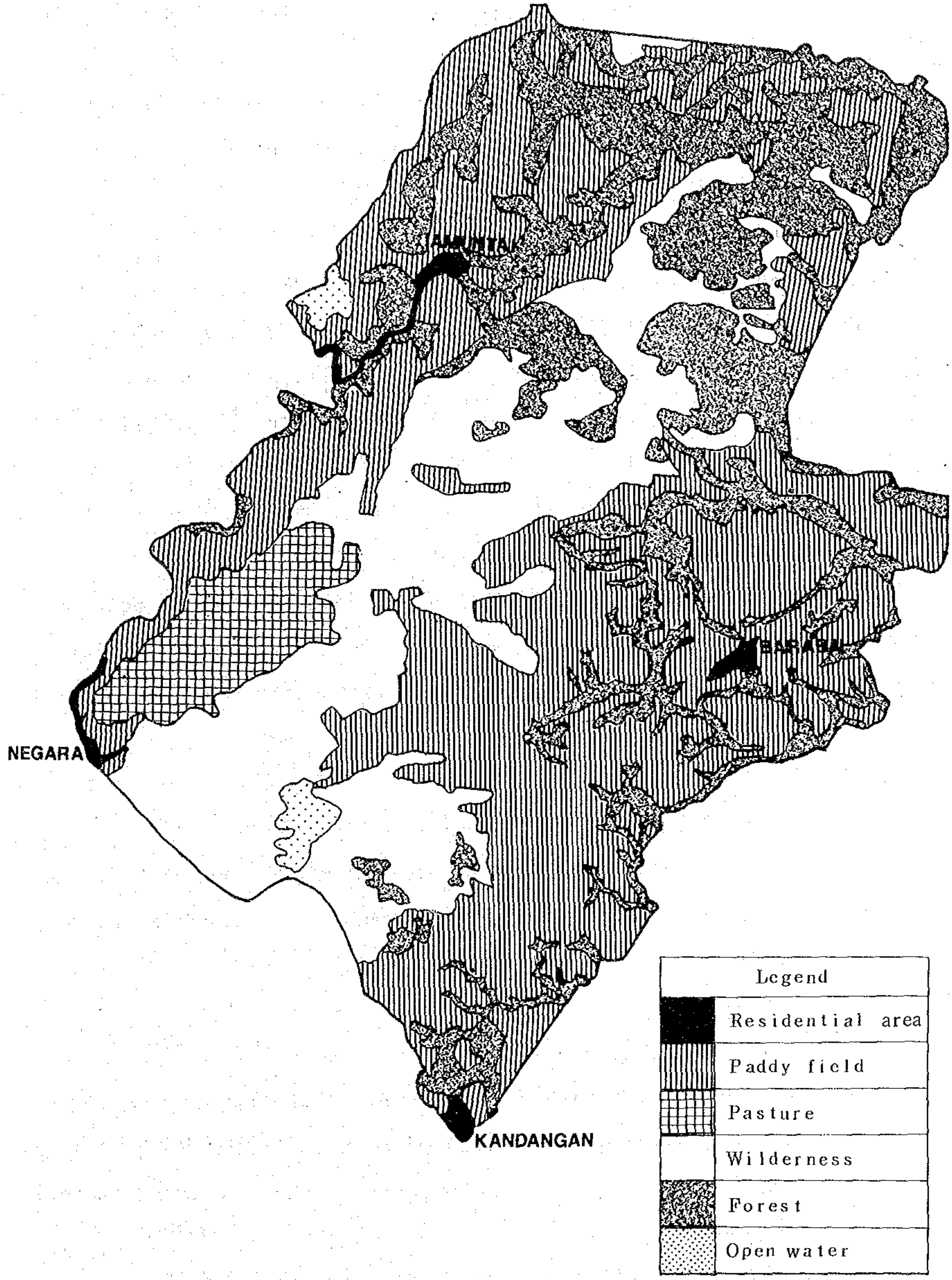


Fig. 1.4 Land-use Map

field, form typical landscape of the area. Natural forest occupies vast area in swampy area in the northern part of the area. In swamp, fishery is also conducted. In dry season, fishing nets are laid on all over the tributaries and Lake Bankau.

1-4 Survey Plan

The survey is scheduled to execute as a three-year program beginning in July 1983, consisting of the following three phases. The survey progressed as scheduled and completed by the end of March 1986. The progress of the survey is shown in Tab. II-1.

1-4-1 Phase I

a. Selection and monumentation of geodetic control points

For the photomapping area, 22 horizontal control points (one point was added in phase II) and 29 vertical control points shall be selected and monumented.

b. Signalization

Aerial photo signals shall be established on 23 horizontal control points (22 newly selected points and one existing point).

c. Aerial photography

Black and white panchromatic aerial photography shall cover the whole project area of about 6,300km^2 (Fig. 1.1) at the scale of 1/20,000 in dry season using wide angle aerial camera.

1-4-2 Phase II

a. Satellite geodesy

As given points for traversing, two points shall be established. As one of them, a point already established by Indonesian side by satellite geodesy shall be taken as the datum for the whole survey and the other point shall be established by satellite geodesy in translocation mode with respect to the above datum point.

b. Traversing

The above two points established by satellite geodesy being taken as given points, 23 horizontal control points shall be established by traversing. (Accuracy: 1/10,000) They shall be used for horizontal control for orientation of aerial photos.

c. Direct levelling

Starting from the existing second order bench marks, the third order levelling (accuracy: 10 mm$\sqrt{S}$, where S is the route length and expressed in km) shall be carried out for 358km (including 29 bench marks and 25 horizontal control points) and minor order levelling (accuracy: 60mm $\sqrt{S}$) for 54km. At the same time pricking of photos shall be carried out along the levelling routes for vertical control for orientation of aerial photos.

d. Indirect levelling

For 11 spots where neither direct nor trigonimetric levelling is feasible, indirect levelling using water surface shall be executed. The spots shall be marked by pricking aerial photos.

e. Aerial photography in rainy season

In order to clarify the state of the photomapping area in rainy season, especially that of water covered area, black and white panchromatic aerial photography shall be carried out at the scale of about 1/20,000 covering the area of about 1,200km^2 by using wide angle aerial camera.

f. Field reconnaissance in rainy season

Field reconnaissance in rainy season shall be executed for the photomapping area to get information useful for photo-interpretation of aerial photos taken both in dry and especially in rainy seasons.

1-4-3 Phase III

a. Field identification (for photomapping)

Collection and confirmation shall be carried out of materials for annotation on photomap, such as administrative names, geographical names, administrative boundaries, etc.

b. Geographical survey

Landform classification, vegetation distribution and land-use mode interpreted from aerial photo shall be verified and supplemented in the field.

c. Aerial triangulation

Points on photos shall be read by using coordinate graph and adjustment shall be done by analytical method using electronic computer.

d. Stereo-plotting

Plotting shall be done at the scale of 1/10,000 by using stereoplotter. For flat area, spot height shall be measured and for hilly area intermediate contour lines of 5m interval (when necessary, with supplementary contour lines of 2,5m) shall be plotted.

e. Preparation of photomap and thematic map

Controlled photo mosaic shall be prepared for photomap, on the basis of which manuscripts shall be compiled for photomap and thematic map from machine-plotted data and materials obtained in the field. Neat lines shall correspond to 6km x 6km (60cm x 60cm on the map). Sheet index is shown in Fig. 1.5.

f. Cartography and printing

Based on compiled manuscripts, final drawings shall be prepared; contour lines and necessary enclosures are drawn by scribing, masks are made by optical stripping and annotation by photo-composing. The composite positive films are made from colour separations so that printing plate for each colour can be made by one plate-making process. Printing is done by offset printing. The photomap shall be printed in two colours and the thematic map in six collours.

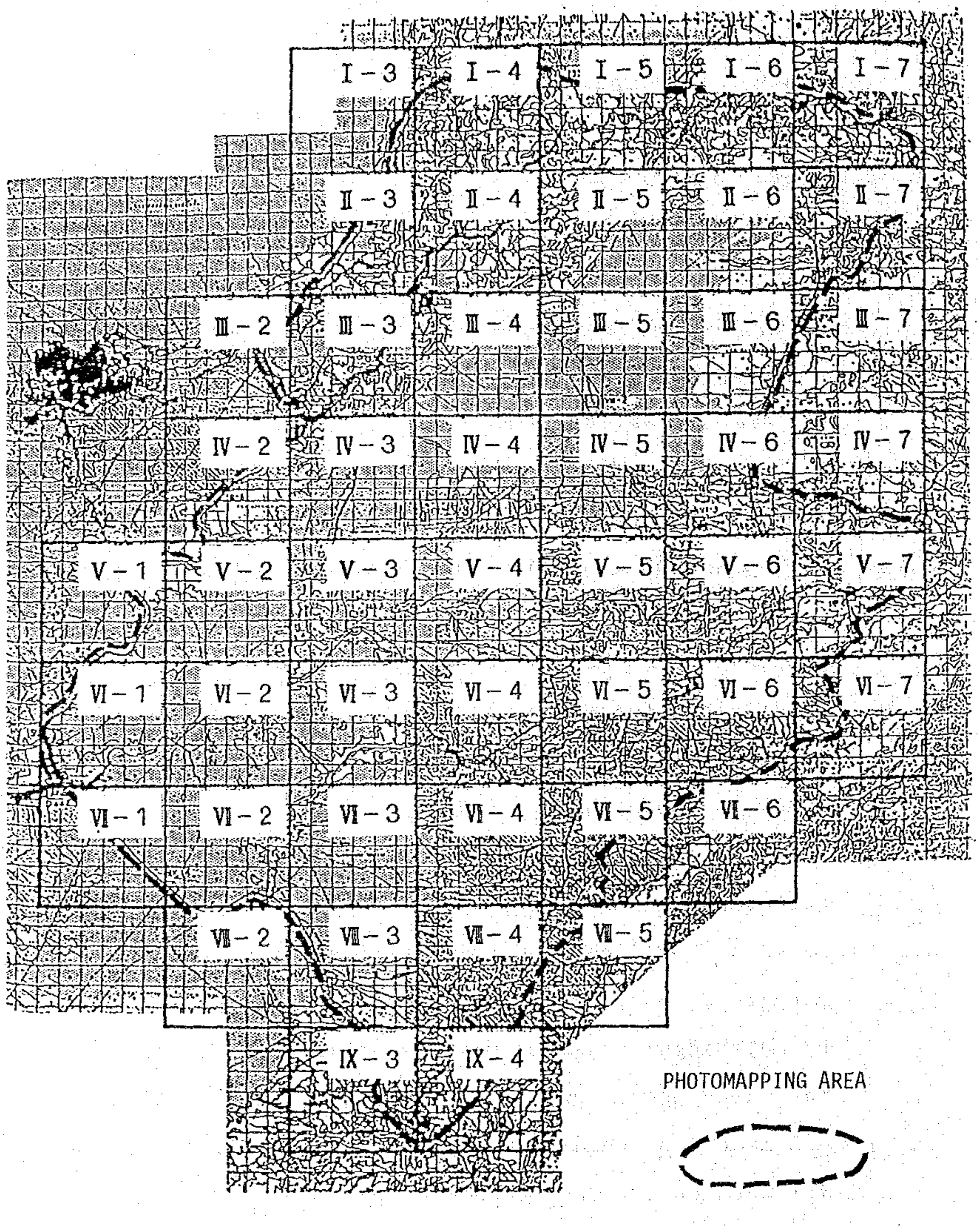


Fig. 1.5 Sheet Index

2. Selection and Monumentation of Geodetic Control Point and Signalization for Aerial Photography

2-1 Summary

As vast swampy zone extends in the survey area, there are many regions of difficult access. Consequently, geodetic control points are planned to distribute along existing roads. Allocation was planned taking into account of good use not only of the present project, but also of future projects of feasibility study (F/S) or detailed design (D/D).

2-2 Selection of Geodetic Control Point

Full consideration was taken for the selection of control points for the sake of following procedures of monumentation and observation, their future occupation and preservation as follows:

a. In order to avoid damage from vehicle, points are allocated in the garden of private houses or on the site of public establishments.

b. As there are many swampy areas in the survey area, care must be taken to avoid soft ground for monumentation as much as possible.

c. As aerial photo signal shall be established at horizontal control point, the point must be allocated on the spot where aerial photo signal is visible from the airplane and easily identifiable on the aerial photo.

Especially, vertical control points were selected so that they might be evenly distributed with the existing bench marks established by the topographic mapping project of the Barito River basin executed by OTCA in 1972.

2-3 Monumentation of Geodetic Control Point

Monumentation was carried out in conformity with Indonesian specifications. Two types of monumentation were applied: for normal ground by type-A and for soft ground by type for swampy zone. (Fig. 2.1)

Monumentation of horizontal control points was executed jointly by Japanese and Indonesian sides and that of vertical control points by Indonesian side alone.

2-4 Signalization for Aerial Photography

Aerial photo signals were established for 23 horizontal control points except for D-642 and HV-24 which were selected in the second year (phase II) of the project in accordance with the specifications as follows:

a. Shape : a cross (four wings)

b. Size : 60cm x 100cm (for one wing)

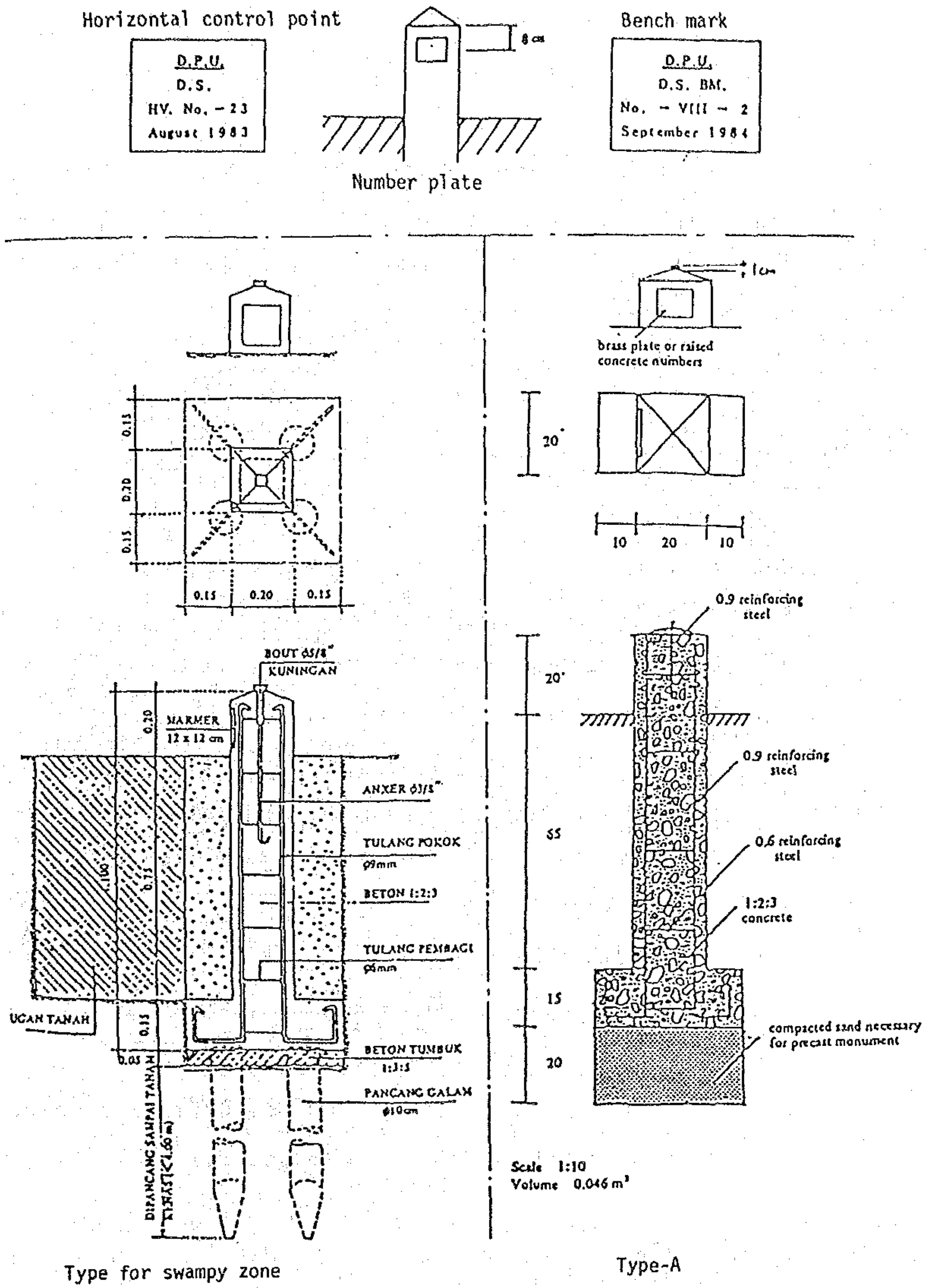


Fig. 2.1 Specifications for Monumentation of Geodetic Control Point

c. Material: veneer (5mm thick)

d. Colour : light yellow (with paint)

At the same time point description notes were also prepared for the convenience of following procedures of the work. Transfer of the position of D-642 and HV-24 on the aerial photo, however, was carried out by pricking aerial photos.

3. Aerial Photography

3-1 Summary

Aerial photography was executed by subcontracting with a local aerial survey firm, P.T. EXSA International, who was selected, taking account of equipments, experiences, cost, etc., among the firms in a short list submitted by DPU.

The work was done once in dry season and once in rainy season. The covered area is shown in Fig. 1.1 and the photo indices are shown in Figs. 3.1 and 3.2.

3-1-1 Aerial Photography in Dry Season

Based on the Samusudin Noor Airport in the suburbs of Banjarmasin, aerial photography in dry season was done from August 22 to September 20, 1983, covering the area of about 6,300km^2 including the photomapping area of about 1,200km^2. (Figs. 1.1 and 3.1)

3-1-2 Aerial Photography in Rainy Season

In order to execute regional development projects of water resources, agriculture and so on, it is important to get acquainted with the water covered area and the state of land-use around it in

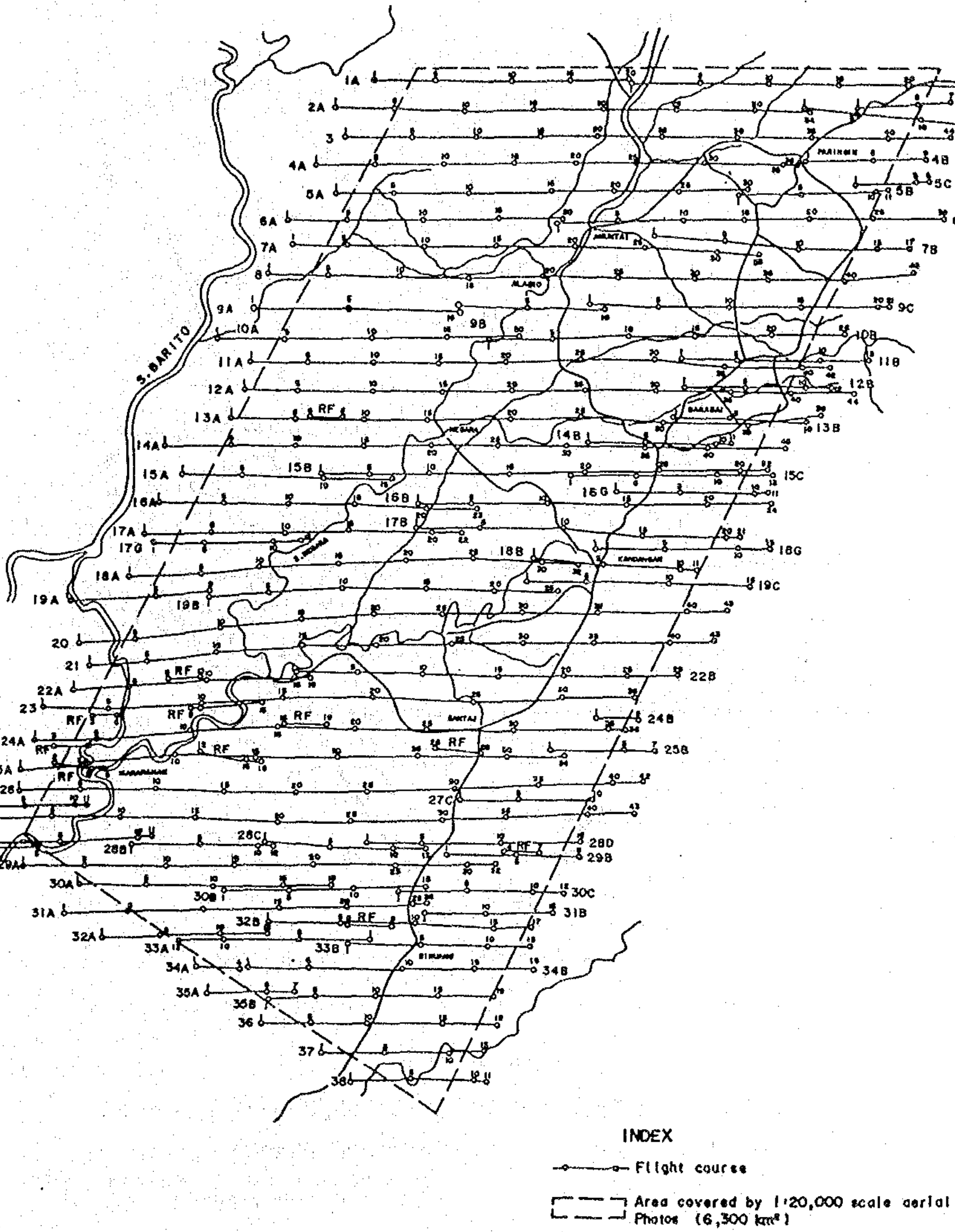


Fig. 3.1 Index Map of Aerial Photography in Dry Season

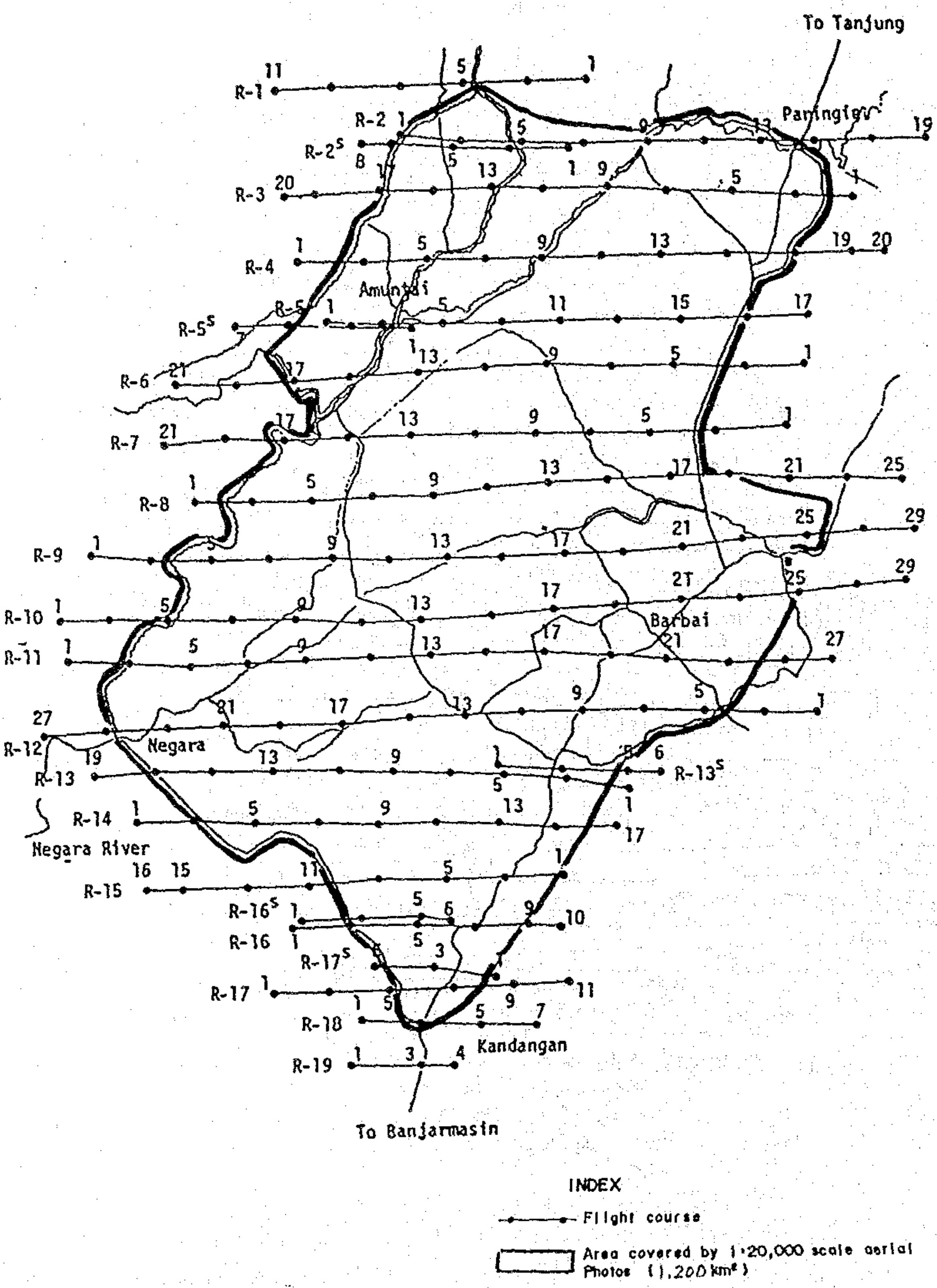


Fig. 3.2 Index Map of Aerial Photography in Rainy Season

rainy season. For the purpose of obtaining materials for photo-interpretation in preparing thematic map, aerial photography was executed from March 9 to 30, 1985, based on the same airport as that used in dry season, covering the photomapping area (1,200km^2).

Having taken time to get clearance of aerial photography, the work could not started until the middle of March. It was worried about the fall down of water level in swampy area, but meanwhile, it rained so hard as to take aerial photos which enabled to grasp the state of water level in rainy season.

3-1-3 Inspection and Annotation

In conformity with the specifications, processed aerial photos were inspected provisionally in the field and after confirming that they would not affect smooth execution of succeeding procedures, following notations were inscribed:

Roll number of film	Project name	Project symbol	Photography date	Photography scale	Course number	Photo number
ROLL VI	NEGARA RIVER DOWN-STREAM	P3SA	AUG-SEPT 1983	1:20,000	R.33B	(1-13)

On the first and last photos, the above all items were inscribed. On other photos, only course and photo numbers were inscribed.

Existing 1/50,000 scale topographic maps were used to prepare index map, where, when one course was flown more than two times, alphabetical letters A, B, C, ... are suffixed to the course number starting generally from western side.

3-2 Specifications

The specificstions for aerial photography are as follows:

Item	Dry season	Rainy season
Scale	1/20,000	1/20,000
Flight height	approx. 3,000m.	approx. 3,000m.
Area covered	approx. 6,300km^2	approx. 1,200km^2
Flight direction	east-west	east-west
Overlap	60% + 5%	60% ± 5%
Side lap	30% + 5%	30% ± 5%
κ	not more than 10°	not more than 10°
φ	not more than 5°	not more than 5°
ω	not more than 5°	not more than 5°
Amount of cloud	for successive 5 photos not more than 3%	for successive 5 photos not more than 10% (Plotting shall be secured.)
Camera	MRB 15/2323 or RMK 15/23 with yellow filter f = 15cm.	MRB 15/2323 or RMK 15/23 with yellow filter f = 15cm.
Film	panchromatic film	panchromatic film
Printing paper	Kodak RC paper	Kokak RC paper

3-3 Results

Results of aerial photography are as follows:

	Dry season	Rainy season
Days needed	30 days	22 days
Number of flight courses	90 courses	19 courses
Number of photos	1,720 pieces	382 pieces

4. Geodetic Control Point Survey and Pricking of Aerial Photo

The provisional results of the geodetic control point survey have already been reported in [5]. In the present report, final results will be given.

4-1 Satellite Geodesy

In Indonesia, BAKOSURTANAL has been establishing geodetic networks by satellite geodesy (site length being about 200km in average). Implementation is realized by Doppler observation of NNSS in point positioning mode by using precise ephemeris or translocation mode.

In the present survey area, there is one point established by the above method (D-642). Another point was established by the present survey by satellite geodesy (HV-24) and minor order geodetic control points were established by traversing based on D-642 and HV-24. (Fig. 4.1)

The elements of the reference ellipsoid of the geodetic coordinate system, ID-1974 (corresponding to GRS-67), are

major axis 6,378,160m. and ellipticity 1/298.247.

The datum of the coordinate system is set at Padang, Sumatera, with the following values:

latitude	0° 56' 38."414S
longitude	100° 22' 08."804E
height (above the reference ellipsoid)	3.19m
height (above the mean sea level)	14.0m

This is the coordinate system widely used in Indonesia.

The ellipsoid to which the satellite geodesy is referred is NWL-9D for precise ephemeris computation, having following elements:

major axis 6,378,145m and ellipticity 1/298.25.

Transformation elements from NWL-9D to ID-1974 are

$$\Delta X = -2.691m$$

$$\Delta Y = +14.757m$$

$$\Delta Z = -0.224m$$

4-1-1 Observation

Observation was made simultaneously at two points (D-642 and HV-24) using one JMR-1 and one JMR-4AT, respectively. Number of passes observed and adopted in adjustment are as follows:

Name of point	Number of passes observed	Number of passes adopted
D-642	81	38
HV-24	130	

4-1-2 Computation

Observed data were processed by the program package GEODOP-V developed by the Earth Physics Branch, Department of Energy, Mines and Resources, Canada, and modified by the Hannover University, West Germany. The two points were simultaneously adjusted by the short arc multi-station solution using broadcast ephemeris. Standard deviations of adjusted values are as follows:

Adopted number of passes 38 passes

Absolute accuracy (point positioning)	latitude	longitude	height
D-642	0."184	0."161	$5.^{m}345$
HV-24	0. 184	0. 163	5. 358
Relative accuracy (translocation)	0. 017 ($0.^{m}51$)	0. 030 ($0.^{m}90$)	0.616

In the above table, absolute accuracy is derived as the program GEODOP-V allows to compute coordinate values of each point separately, while relative accuracy is derived from difference of coordinate values of each corresponding pairs of simultaneous observation. Concerning the results of separate solution, reference is made to paragraph 14-1.

The elements of the reference ellipsoid used, WGS-72, are as follows:

major axis 6,378,135m and ellipticity 1/298.26

It is assumed that the origin and the direction of axes are coincident with those of NWL-9D, the ellipsoid to which computation by using precise ephemeris is referred.

4-1-3 Result

Based on the given values of D-642

		S.D.
latitude	2° 37' 55."890 S	0."062 (1.86m)
longitude	115° 06' 36."704 E	0."063 (1.89m)
height above ellipsoid	45.2m	1.9m

and U.T.M. coordinates (Zone number 50)

N = 9,708,901.525m

E = 289,893.515m,

the coordinate values of the new point HV-24 are obtained as follows:

latitude	2° 20' 05."398 S	0."064 (1.92m)
longitude	115° 27' 38."038 E	0."070 (2.10m)
height above ellipsoid	66.2m	2.0m

and U.T.M. coordinates (Zone number 50)

N = 9,741,834.803m

E = 328,819.518m,

where standard deviations of the coordinate values of HV-24 are statistical sums of the given standard deviations of D-642 and those of coordinate difference of D-642 and HV-24 obtained from relative observation of these points.

4-2 Traversing

4-2-1 Observation

Traversing was executed in order to determine the position of 23 horizontal control points, with two points established by satellite geodesy as given points. As shown in Fig. 4.1, 4 closed routes and one open route (ⓚ in Fig. 4.1) were formed. On 8 points, azimuth was determined by solar observation to adjust direction angles between 2 points where azimuth was determined. Specifications for traversing are as follows:

(1) Distance measurement

a.	Instruments used	: H.P. 3808A, H.P. 3800B, Topcon distance meter
b.	Number of observations in one set	: 3 times
c.	Number of observation sets	: 1 set
d.	Discrepancy of observation	: not more than 5cm

(2) Horizontal angle observation

a.	Instrument used	: Wild T-2

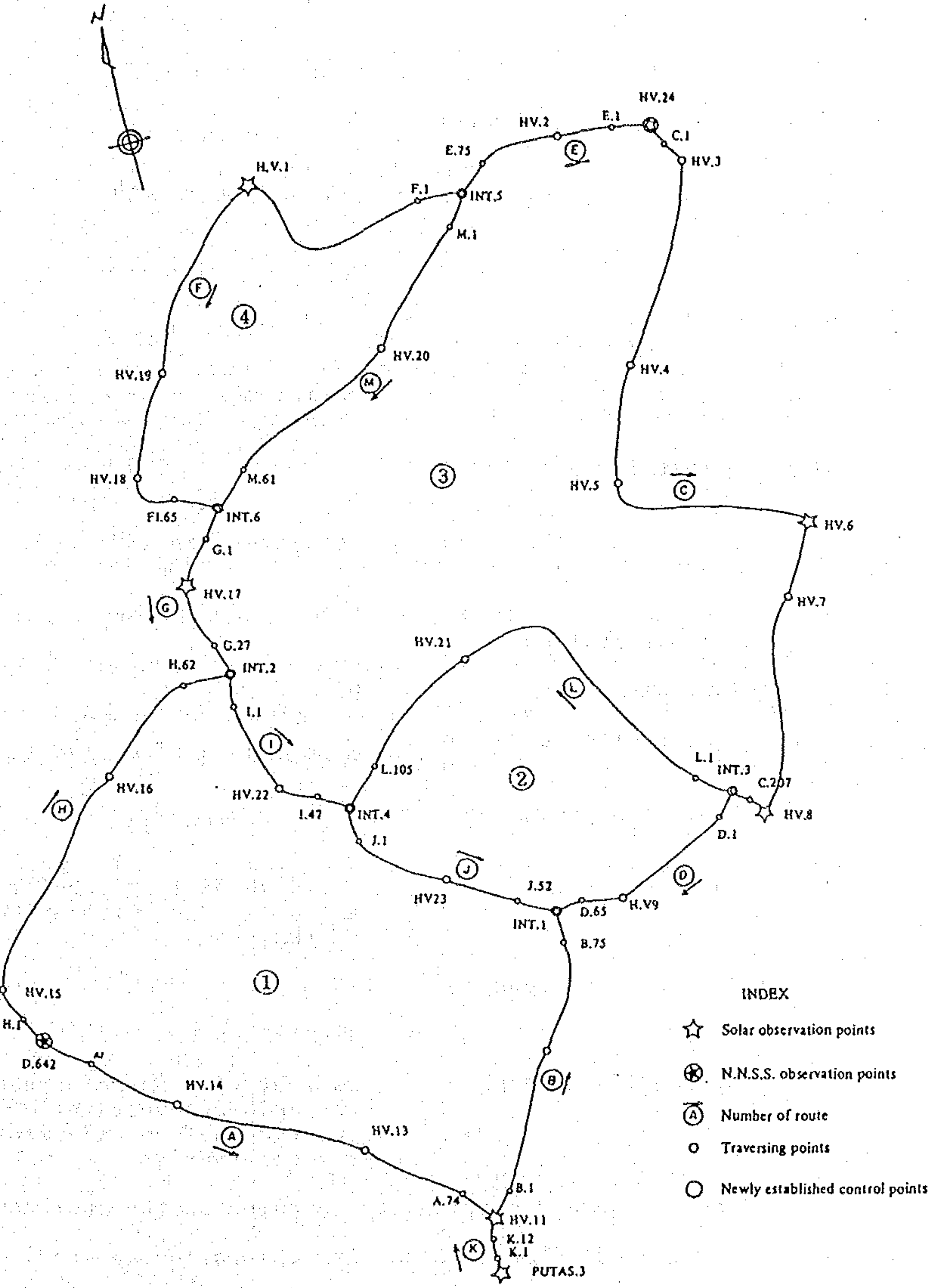


Fig. 4.1 Traversing Network Map

b. Observation of one set : normal and reverse observations

c. Number of observation sets : 2 sets

d. Difference in observations : not more than 15"

e. Double angle difference: not more than 25"

f. Graduated circles used : 0° and 90°

(3) Vertical angle observation

a. Observation of one set : normal and reverse observations

b. Number of observation sets : 1 set

c. Constant of elevation : not more than 25"

(4) Azimuth observation

a. Instrument used : Wild T-2

b. Number of observation sets : more than 5 effective sets

c. Discrepancy between sets : not more than 30"

d. Observation time : avoid about 1 hour before and after the culmination of the sun

e. Unit of time reading : 1"

f. Watch used : digital watch

g. Correction to time : correct time in reference to radio announcement of the time before and after the observation

Observed results were provisionally computed on the spot and their quality was judged in accordance with the following conditions. Re-observation was made when they exceeded the conditions.

a. Closure of direction angle: $10''\sqrt{n}$

b. Closure of coordinates : 1/10.000

c. Closure of relative height: $8\ \text{cm}\,\Sigma s/\sqrt{l}$,

where,

n = number of directions observed

l = number of sites observed

s = route length in km

There are many nodal points on the routes in comparison with route length, because routes were generally winding, average distance between nodal points being more or less 250m. However, it was able to make observation within the proposed observation accuracy.

After adjusting for closures, approximate coordinates of new points were computed for net adjustment. Direction angle was corrected, using observed azimuth, by distributing errors in simple routes and by adjusting errors in complex routes. Vertical angle was used only for horizontal reduction of observed distance. (Height was determined by direct levelling.)

Route number	No.1	No.2	No.2 + No.3	No.4
Route length (m)	90,349.831	50,937.746	99,179.543	60,313.877
Number of nodal points	330	230	372	253
Average distance between nodal points (m)	274	221	256	238
Closure of coordinates ΔX (m)	3.985	-1.036	7.733	0.776
ΔY (m)	-1.317	1.191	1.640	3.328
Ratio of closure of coordinates to route length	1:27,000	1:32,000	1:12,000	1:17,000

Tab. 4.1 Observation Accuracy of Traversing

4-2-2 Computation

Net adjustment was done by XY net adjustment.

(1) Coordinate system

Reference ellipsoid	:	ID-1974 (paragraph 4-1)
Coordinate system	:	U.T.M. Zone 50
central meridian	λ_0	= 117°E
latitude	φ_0	= 0°
Datum of the coordinate system:		N_o = 10,000,000.0m
		E_o = 500,000.0m

(2) Number of given points

Two points : D-642 and HV-24

(3) Number of new points

Horizontal control points	:	23
Nodal points	:	1040
Total	:	1067

(4) Observation equations [6]

1) Distance

$$v(s_{12}) = \frac{v_s}{s'_{12}} \cdot \rho'' = -b_{12}\,\Delta x_1 - a_{12}\,\Delta y_1 + b_{12}\,\Delta x_2 + a_{12}\,\Delta y_2 - \frac{s_{12} - s'_{12}}{s'_{12}} \cdot \rho''$$

2) Direction angle

$$v(t_{12}) = -\Delta Z_1 + a_{12}\,\Delta x_1 - b_{12}\,\Delta y_1 - a_{12}\,\Delta x_2 + b_{12}\,\Delta y_2 - l_{12}$$

3) Azimuth

$$v(a_{12}) = a_{12}\,\Delta x_1 - b_{12}\,\Delta y_1 - a_{12}\,\Delta x_2 + b_{12}\,\Delta y_2 - m_{12}$$

where,

$$s'_{12} = \sqrt{(x'_2 - x'_1)^2 + (y'_2 - y'_1)^2}$$

$$t'_{12} = \tan^{-1}\left(\frac{y'_2 - y'_1}{x'_2 - x'_1}\right)$$

$$t_{12} = Z'_1 + U_{12} - t'_{12}$$

$$m_{12} = A_{12} + \gamma + (t_{12} - T_{12}) - t'_{12}$$

$$a_{12} = \frac{y'_2 - y'_1}{s'^2_{12}} \cdot \rho''$$

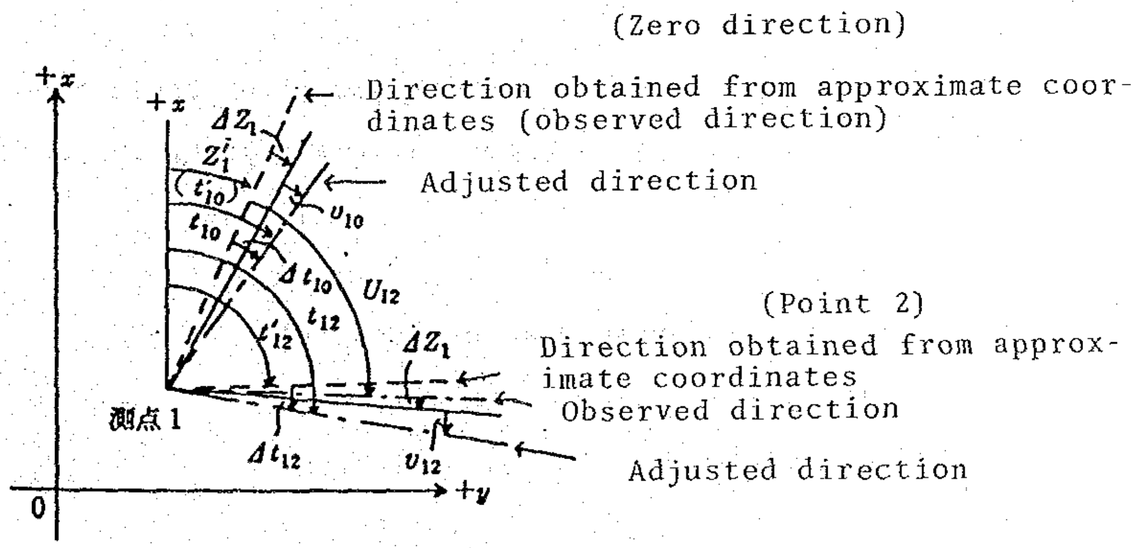
$$b_{12} = \frac{x'_2 - x'_1}{s'^2_{12}} \cdot \rho''$$

$$x_1 = x'_1 + \Delta x_1$$

$$y_1 = y'_1 + \Delta y_1$$

$$x_2 = x'_2 + \Delta x_2$$

$$y_2 = y'_2 + \Delta y_2$$



x_i, y_i	:	most probable values of x, y coordinates of point i
x_i', y_i'	:	approximate values of x, y coordinates of point i
Δx_i, Δy_i	:	corrections to x, y coordinates of point i
s_{12}	:	measured distance from point 1 to 2 on the xy coordinate plain
ΔZ_1	:	orientation error (correction to standard angle)
Z_1'	:	standard angle (direction angle obtained from approximate coordinates of point 1 and its zero direction)
U_{12}	:	angle at point 1 on the x, y coordinate plain included by the zero direction and the direction to point 2
A_{12}	:	geodetic azimuth from point 1 to 2
γ	:	meridian convergence at point 1
$(t_{12} - T_{12})$	:	correction to the direction from point 1 to 2
Δt_{ij}	:	correction to direction angle from point i to j computed from approximate coordinates

(5) Weight of observation equations [6]

1) Distance

$$P_S = \frac{m_t^2 S^2}{(m_S^2 + \gamma^2 S^2)\rho''^2}$$

2) Direction angle

$$P_t = \frac{N_t}{N}$$

3) Azimuth

$$P_A = \frac{N_A}{N}$$

where,

- S : measured distance
- m_s : mean square error arising irrespective of the length of measured distance in distance measurement by distance meter
- r : proportional constant of the error proportional to the length of measured distance in distance measurement by distance meter
- m_t : mean square error of one direction of an angle
- N : proposed number of sets of observation
- N_t : number of sets of actual observation of direction angle
- N_A : number of sets of actual observation of azimuth

[Note 1] P_S is defined so as to P_t equals 1.

[Note 2] P_t in 2) is regarded in principle as 1.

[Note 3] N_A shall be determined so that the weight of observation equation of azimuth may be 1, where one point is fixed and one direction is specified.

No.	N	E	Latitude	Longitude	Grid Convergence
D.S.-H.V.-No.-1	9744765.675m	310359.292m	S 2°18′29″.28998	E 115°17′40″.67222	+ 0° 4′ 7″.3
D.S.-H.V.-No.-2	9742259.528	324514.883	S 2 19 51.41521	E 115 25 18.72581	+ 0 3 51.1
D.S.-H.V.-No.-3	9739678.851	329770.441	S 2 21 15.62567	E 115 28 8.74010	+ 0 3 46.5
D.S.-H.V.-No.-4	9731621.623	324708.986	S 2 25 37.76317	E 115 25 24.61487	+ 0 4 .4
D.S.-H.V.-NO.-5	9726481.566	322592.299	S 2 28 25.02673	E 115 24 15.90266	+ 0 4 8.0
D.S.-H.V.-No.-6	9721787.220	330812.214	S 2 30 58.17971	E 115 28 41.80627	+ 0 4 .6
D.S.-H.V.-No.-7	9718583.243	328789.128	S 2 32 42.41668	E 115 27 36.19272	+ 0 4 6.2
D.S.-H.V.-No.-8	9709076.953	324755.441	S 2 37 51.75572	E 115 25 25.23241	+ 0 4 20.6
D.S.-H.V.-No.-9	9707095.722	317481.283	S 2 38 55.95144	E 115 21 29.65976	+ 0 4 33.2
D.S.-H.V.-No.-10	9700985.565	312110.325	S 2 42 14.63406	E 115 18 35.51446	+ 0 4 47.1
D.S.-H.V.-No.-11	9694128.412	307385.151	S 2 45 57.64830	E 115 16 2.22384	+ 0 5 1.1
D.S.-H.V.-No.-12	9691511.789	306961.301	S 2 47 22.81071	E 115 15 48.37734	+ 0 5 4.4
D.S.-H.V.-No.-13	9699262.572	302640.838	S 2 43 10.28400	E 115 13 28.87618	+ 0 5 3.3
D.S.-H.V.-No.-14	9703809.477	295080.588	S 2 40 41.90188	E 115 9 24.35768	+ 0 5 10.2
D.S.-H.V.-No.-15	9711333.321	288921.659	S 2 36 36.68327	E 115 6 5.36599	+ 0 5 11.4
D.S.-H.V.-NO.-16	9719612.310	296003.090	S 2 32 7.52156	E 115 9 54.96486	+ 0 4 52.3
D.S.-H.V.-No.-17	9727330.654	302322.040	S 2 27 56.54701	E 115 13 19.83157	+ 0 4 35.4
D.S.-H.V.-No.-18	9733057.376	301482.951	S 2 24 50.08441	E 115 12 52.91939	+ 0 4 30.8
D.S.-H.V.-No.-19	9737432.408	304059.580	S 2 22 27.76840	E 115 14 16.49421	+ 0 4 22.9
D.S.-H.V.-No.-20	9735744.235	314100.284	S 2 23 23.13399	E 115 19 41.39683	+ 0 4 11.0
D.S.-H.V.-No.-21	9719994.868	313840.741	S 2 31 55.85408	E 115 19 32.35658	+ 0 4 26.4
D.S.-H.V.-NO.-22	9716666.265	303527.251	S 2 33 43.76774	E 115 13 58.37276	+ 0 4 44.5
D.S.-H.V.-No.-23	9710515.512	309931.520	S 2 37 4.28810	E 115 17 25.40610	+ 0 4 41.2
D.S.-H.V.-No.-24	9741834.803	328819.518	S 2 20 5.39845	E 115 27 38.03770	+ 0 3 45.8
D - 642	9708901.525	289893.515	S 2 37 55.89002	E 115 6 36.70400	+ 0 5 12.6

Tab. 4.2 Final Results of Horizontal Control Points

ST.		M.E.	ST.		M.E.
HV-1	N	.777 *m*	HV-13	N	.744 *m*
	E	.539		E	.515
	$\sqrt{N^2+E^2}$	.946		$\sqrt{N^2+E^2}$	.905
2		.355	14		.375
		.144			.375
		.383			.531
3		.122	15		.104
		.198			.208
		.232			.233
4		.500	16		.473
		.850			.612
		.986			.774
5		.647	17		.838
		1.162			.778
		1.330			1.143
6		.963	18		.879
		1.425			.763
		1.720			1.164
7		.938	19		.798
		1.343			.689
		1.638			1.055
8		.970	20		.834
		.946			.647
		1.355			1.056
9		.899	21		.847
		.957			.904
		1.313			1.238
10		.804	22		.826
		.841			.809
		1.163			1.156
11		.756	23		.820
		.658			.951
		1.002			1.256
12		.026			
		.044			
		.051			

Tab. 4.3 Standard Deviation of Control Points (1)

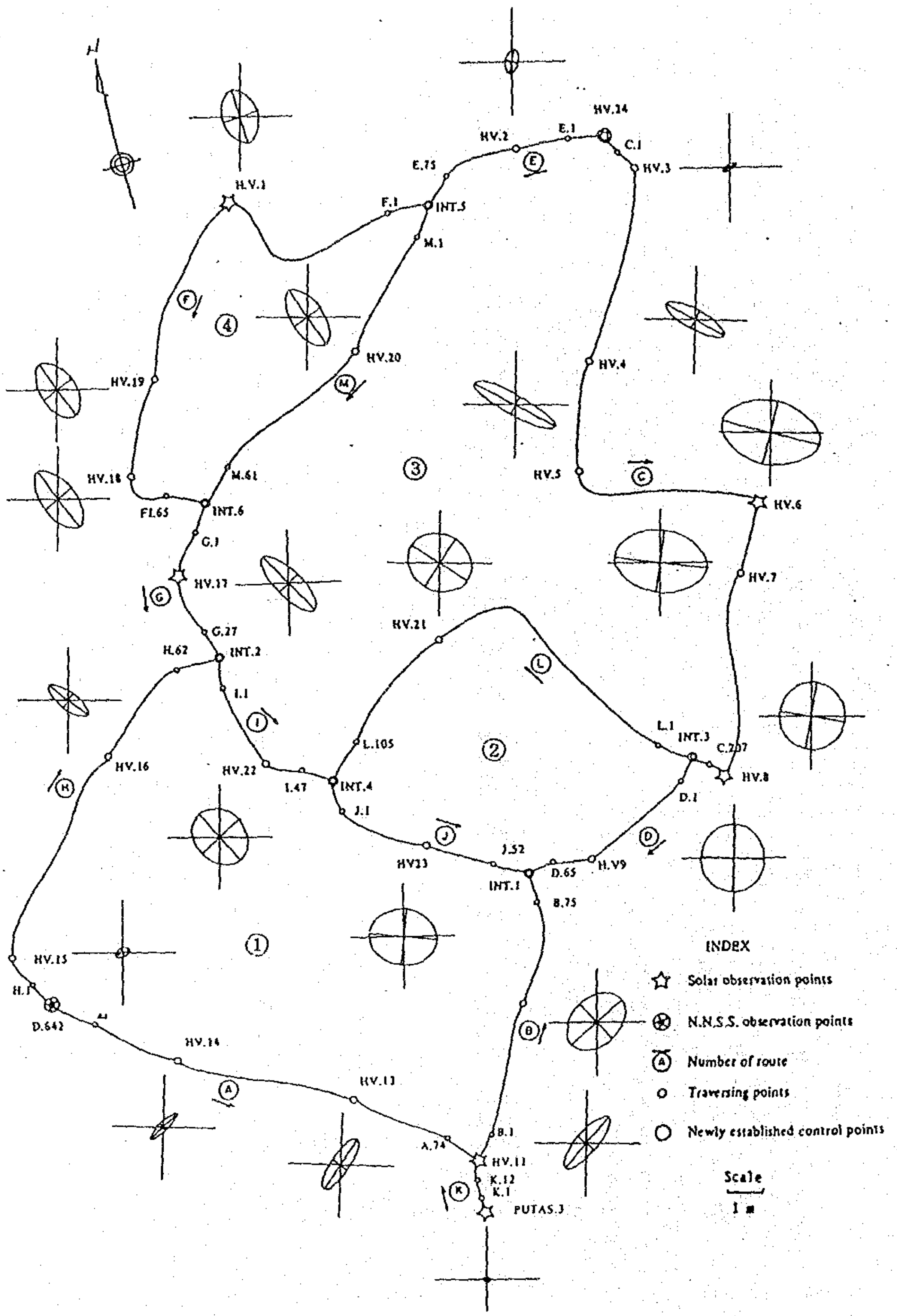


Fig. 4.2 Error Ellipses of Control Points

(6) Provision of mean square errors to observed values

Following elements were provided as mean square errors of observations to determine weights of observation equations:

$$m_s = 15mm$$

$$\gamma = 3.0 \times 10^{-6}$$

$$m_t = 3.5''$$

4-2-3 Results

In Tab. 4.2 are given the coordinate values of horizontal control points after adjustment, where height is obtained by direct levelling.

Standard deviations of each point are given in Tab. 4.3 and the maximum, minimum and average values are given in Tab. 4.4. The error ellipses are shown in Fig. 4.2.

Item	N	E	$\sqrt{N^2 + E^2}$
Minimum	0.026m	0.044m	0.051m
Maximum	0.963	1.425	1.720
Average	0.665	0.771	0.984

Tab. 4.4 Standard Deviation of Control Points (2)

4-3 Levelling

In the survey area, there are two second order levelling routes (accuracy: 7.5 mm$\sqrt{S}$, where S is route length in km). One route starts at Takisong facing on the Jawa Sea, passes through Martapura, Kanadangan, Pantai Hambawang Timur and Amuntai and arrives at Tanjung. It was established by OTCA (now JICA) in 1972 based on the mean sea level obtained from tide observation at Takisong. The other starts at Pantai Hambawang Timur, passes through Barabai and Abung Makmur and arrives at Lok Batumandi. It was established by DPU in 1982 based on the established height of the bench mark PUTL-5 in 1972 by OTCA. (Fig. 4.3)

In order to increase the number of vertical control points in the survey area, bench marks were set up along the highways and observed by the third order levelling (accuracy: 10 mm $\sqrt{S}$). At the same time, existing second order bench marks were checked by the third order levelling to select the existing points to be based on for the present survey.

For the sake of vertical control for aerial triangulation, however, it was necessary to distribute vertical control points areally homogeneous as much as possible. Starting from the established third order bench marks, minor order vertical control points were established outside the thirder order levelling routes by direct levelling of the accuracy of 60 mm $\sqrt{S}$ or indirect levelling by using water surface intermediately for the area where direct levelling or trigonometric levelling was not feasible (Fig. 4.4).

While executing surveys, pricking was carried out on aerial photos for vertical control points and other spots considered necessary as vertical control for aerial triangulation and plotting.

4-3-1 Checking of Existing Points [3]

Existing second order bench marks were checked by the third order levelling in order to select the points to use as given points for the present third order levelling. Results of the check observation are given in Tab. 4.5 with the observed values of the preceding surveys.

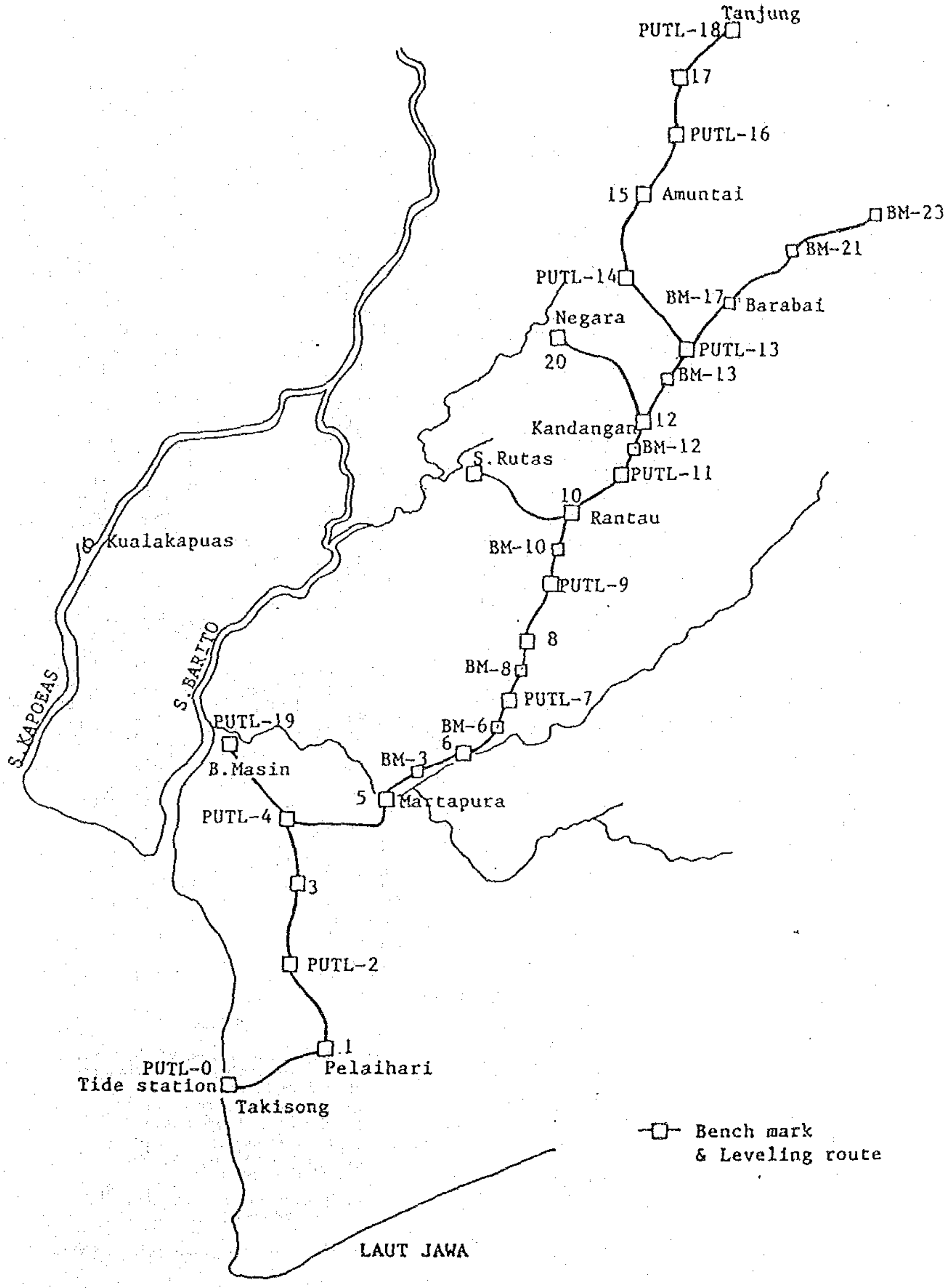


Fig. 4.3 Existing 2nd Order Levelling Routes

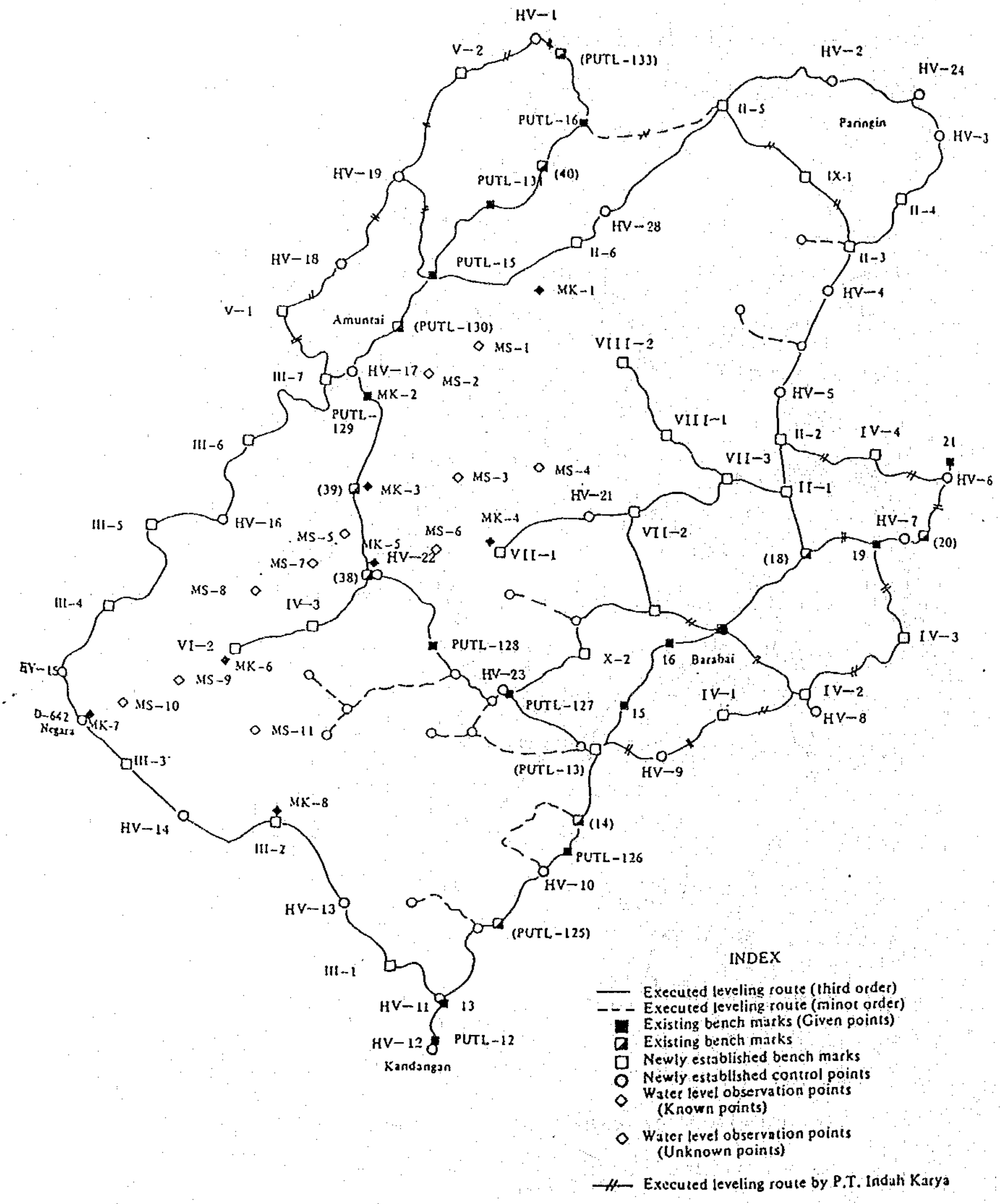


Fig. 4.4 Levelling Network

Observed year (Ovserved agency)	1972 (OTCA)	1982 (DPU)	1984 (JICA)
Point name			
Takisong (Sea level)	0m		
PUTL - 5	6.0277	6.0277m※	
PUTL - 6	8.0227	8.0242	
PUTL-113	9.5426	9.5412	
PUTL - 7	31.4563	31.4902	
PUTL - 8	10.4788	10.5597	
PUTL-117	17.5086	17.5767	
PUTL-118	12.7467	12.7872	
PUTL - 9	6.5753	6.5947	
PUTL-122	9.0378	9.0297	
PUTL -11	17.8897	17.8782	
PUTL-123	9.1468	9.1012	
PUTL -12	10.5012	10.4737	10.5012m※
B.M - 13		7.9135	7.9422
PUTL-125	6.7976	6.7612	6.8302
PUTL-126	6.8363	6.7967	6.8612
PUTL -13	10.1057	10.0772	10.1312
PUTL-127	5.2916		5.3302
PUTL-128	3.8617		3.8802
PUTL-129	3.6176		3.6482
PUTL-130	4.8210		4.8042
PUTL -15	4.8044		4.8202
PUTL-131	5.6878		5.7062
PUTL -16	7.1932		7.2162
PUTL-133	8.2331		8.2152
B.M - 14		9.8388	9.8672
B.M - 15		6.8755	6.9282
B.M - 16		8.5452	8.5882
B.M - 17		11.6414	11.6542
B.M - 18		15.8245	15.8122
B.M - 19		19.2257	19.2302
B.M - 20		21.6077	21.6962
B.M - 21		23.4852	23.4922

※: provisional fixed height

Tab. 4.5 Observed Value of Existing Bench Marks

No.	Elevation
PUTL - 12	10.5012 m
PUTL - 13	10.101 *
PUTL - 15	4.8044
PUTL - 16	7.1932
PUTL - 125	6.815 *
PUTL - 126	6.8363
PUTL - 127	5.2916
PUTL - 128	3.8617
PUTL - 129	3.6176
PUTL - 130	4.782 *
PUTL - 131	5.6878
PUTL - 133	8.192 *
BM-13	7.9385
BM-14	9.840 *
BM-15	6.8990
BM-16	8.5687
BM-17	11.648 *
BM-18	15.822 *
BM-19	19.2492
BM-20	21.714 *
BM-21	23.5074
BM-38	3.050 *
BM-39	2.526 *
BM-40	6.777 *

Note: PUTL-12-PUTL-133 were established in 1972 by O. T. C. A. Japan.
BM-13-40 were established in 1982 by D. P. U.
PUTL-14, PUTL-20 and PUTL-132 were damaged or lost.
*means that the elevation was obtained by the 1984's levelling work.

Tab. 4.6 Final Elevation of Existing Bench Marks

The present survey was based on the height of the bench mark PUTL-12 established in 1972. In principle, when the newly measured value coincides with the result of 1972 within the accuracy of the present survey, the value of 1972 was adopted as given value for the present survey and when it was not consistent to each other, the value of 1982 is adopted, if the newly measured value coincides with it within the accuracy of the present survey. When it coincides with neither the value of 1972, nor that of 1982, the point is regarded as new point. Tab. 4.6 gives the height of existing points after the above chicking, where the mark * shows the value newly determined by the adjustment of the present survey.

4-3-2 Direct Levelling

Direct levelling was executed following the specifications given in Tab. 4.7 using auto-level (Sokkisha B-2 or Wild NAK-2).

Order	3rd order	minor order
Distance between staves	max. 80m	max. 80m
Least reading unit	1mm	1mm
Number of observations	1 sight 1 reading	1 sight 1 reading
Number of run	1	1
Discrepancy in one run	10 mm $\sqrt{S}$	60 mm $\sqrt{S}$
Closure	10 mm $\sqrt{S}$	60 mm $\sqrt{S}$
Closure from one given point to another point	10 mm $\sqrt{S}$	60 mm $\sqrt{S}$

where S is the route length in km.

Tab. 4.7 Specifications for Direct Levelling

A part of the work was executed by subcontracting with a local survey firm, P.T.Indah Karya (Jakarta Branch), who carried

Tab. 4.8 Accuracy of Observation of the Third Order Levelling

Route No.	Length of Route	Limitation of Clossing Error or Discrepancy	Clossing Error	Discrepancy	Note
1	0.449 Km	0.6 cm	—	0.4 cm	Open
2	2.466	1.5	0.4 cm	1.0	
3, 4	11.414	3.3	2.1	2.4	
5, 6	6.202	2.4	0.5	2.1	
7	5.819	2.4	0.8	2.0	
8	5.416	2.3	2.0	0.9	
9, 10, 11	16,039	4.0	1.2	3.3	
12, 13	7.931	2.8	1.4	2.8	
14	5.281	2.3	0.2	0.3	
15, 16	6.730	2.5	0.5	0.7	
17, 37	17.533	4.1	0.2	1.5	
18	2.775	1.6	0.1	0.4	
19	3.283	1.8	1.0	0.3	
20, 21, 22	13,358	3.6	3.2	0.9	
23, 24	7.010	2.6	0.5	0.5	
25	59.522	7.7	2.7	5.3	
26	59.246	7.6	0.4	0.3	
27	12.462	3.5	0.1	0.6	
28	6.219	2.4	0.3	1.2	
29	12.668	3.5	0.7	1.2	
30	10.759	3.2	0.0	0.2	
31	4.195	2.0	0.4	0.3	
32	15.155	3.8	1.3	0.7	
33	9.594	3.0	0.4	1.4	
34	10.413	3.2	1.6	3.1	
35	15.743	3.9	0.3	3.1	
36	7.288	2.6	0.0	0.8	
38	7.911	2.8	—	1.3	Open
39	7.564	2.7	—	1.5	〃
40	6.585	2.5	—	0.6	〃
41	1.266	1.1	—	1.0	〃

Limitation of clossing error or discrepancy : $10\ mm\sqrt{S}$

S = length of leveling route in km

Route No.	Length of Route	Limitation of Clossing Error or Discrepancy	Clossing Error	Discrepancy	Note
101	4.413 Km	12.6 cm	—	2.6 cm	Open
102	8.490	17.4	2.3 cm	2.3	
103	9.052	18.0	—	9.3	Open
104	2.491	9.4	—	1.5	〃
105	6.201	14.9	—	1.2	〃
106	2.467	9.4	—	0.2	〃
107	2.415	9.3	—	0.9	〃
108	3.187	10.7	—	1.6	〃
109	4.024	12.0	—	0.3	〃
110	2.070	8.6	—	1.0	〃
111	8.804	17.8	4.4	2.0	

Limitation of clossing error or discrepancy : 60 mm $\sqrt{S}$
S = Length of Leveling route in km

Tab. 4.9 Accuracy of Observation of Minor Order Levelling out the survey of the routes shown with double slant lines in Fig. 4.4

The lengths of routes observed are as follows:

	Japanese survey team	P.T.Indah Karya	Total
Third order levelling	255 km	103 km	358 km
Minor order levelling	45 km	8 km	53 km
Total	300 km	111 km	411 km

The accuracy of observation is given in Tabs. 4.8 and 4.9. Net adjustment was done for the third order levelling routes on the basis of the established values of existing bench marks given in Tab. 4.6 except those of points marked * in the table. The adjusted height and the standard deviations of the junctions are given in Tab. 4.10. From this table, the range of standard deviation is

maximum 10.6mm, minimum 2.8mm, average 6.0mm.

The height of new third order bench marks obtained by net adjustment computation is given in Tab. 4.11.

	ASS.H	CORR.	ADJ.H	M.E.
	M	M	M	M
(PL13)	10.1010	-.0004	10.1006	.0039
(BM17)	11.6510	-.0025	11.6485	.0046
(BM18)	15.8220	.0002	15.8222	.0049
HV-6	20.9380	.0003	20.9383	.0028
HV-17	4.3070	-.0012	4.3058	.0034
HV-19	4.1420	-.0002	4.1418	.0067
II-1	14.6190	.0020	14.6210	.0061
II-2	12.8940	.0015	12.8955	.0066
II-3	14.3960	.0045	14.4005	.0103
II-5	10.2690	-.0043	10.2647	.0106
III-7	3.6170	-.0006	3.6164	.0053
IV-2	19.4080	-.0018	19.4062	.0064
X-1	10.2270	-.0010	10.2260	.0062

Tab. 4.10 Adjusted Height and Standard Deviation of Junctions

No.	Elevation
D.S.-BM-No.-II-1	14.621 m
D.S.-BM-No.-II-2	12.896
D.S.-BM-No.-II-3	14.400
D.S.-BM-No.-II-4	27.439
D.S.-BM-No.-II-5	10.265
D.S.-BM-No.-II-6	6.756
D.S.-BM-No.-III-1	5.156
D.S.-BM-No.-III-2	2.336
D.S.-BM-No.-III-3	1.923
D.S.-BM-No.-III-4	2.534
D.S.-BM-No.-III-5	2.766
D.S.-BM-No.-III-6	3.317
D.S.-BM-No.-III-7	3.616
D.S.-BM-No.-IV-1	15.140
D.S.-BM-No.-IV-2	19.406
D.S.-BM-No.-IV-3	22.756
D.S.-BM-No.-IV-4	15.104
D.S.-BM-No.-V-1	3.466
D.S.-BM-No.-V-2	6.502
D.S.-BM-No.-VI-2	2.011
D.S.-BM-No.-VI-3	2.056
D.S.-BM-No.-VII-1	3.139
D.S.-BM-No.-VII-2	7.646
D.S.-BM-No.-VII-3	11.340
D.S.-BM-No.-VIII-1	7.190
D.S.-BM-No.-VIII-2	5.922
D.S.-BM-No.-IX-1	24.132
D.S.-BM-No.-X-1	10.226
D.S.-BM-No.-X-2	7.704

Tab. 4.11 Final Height of Newly Established Bench Marks

4-3-3 Indirect Levelling

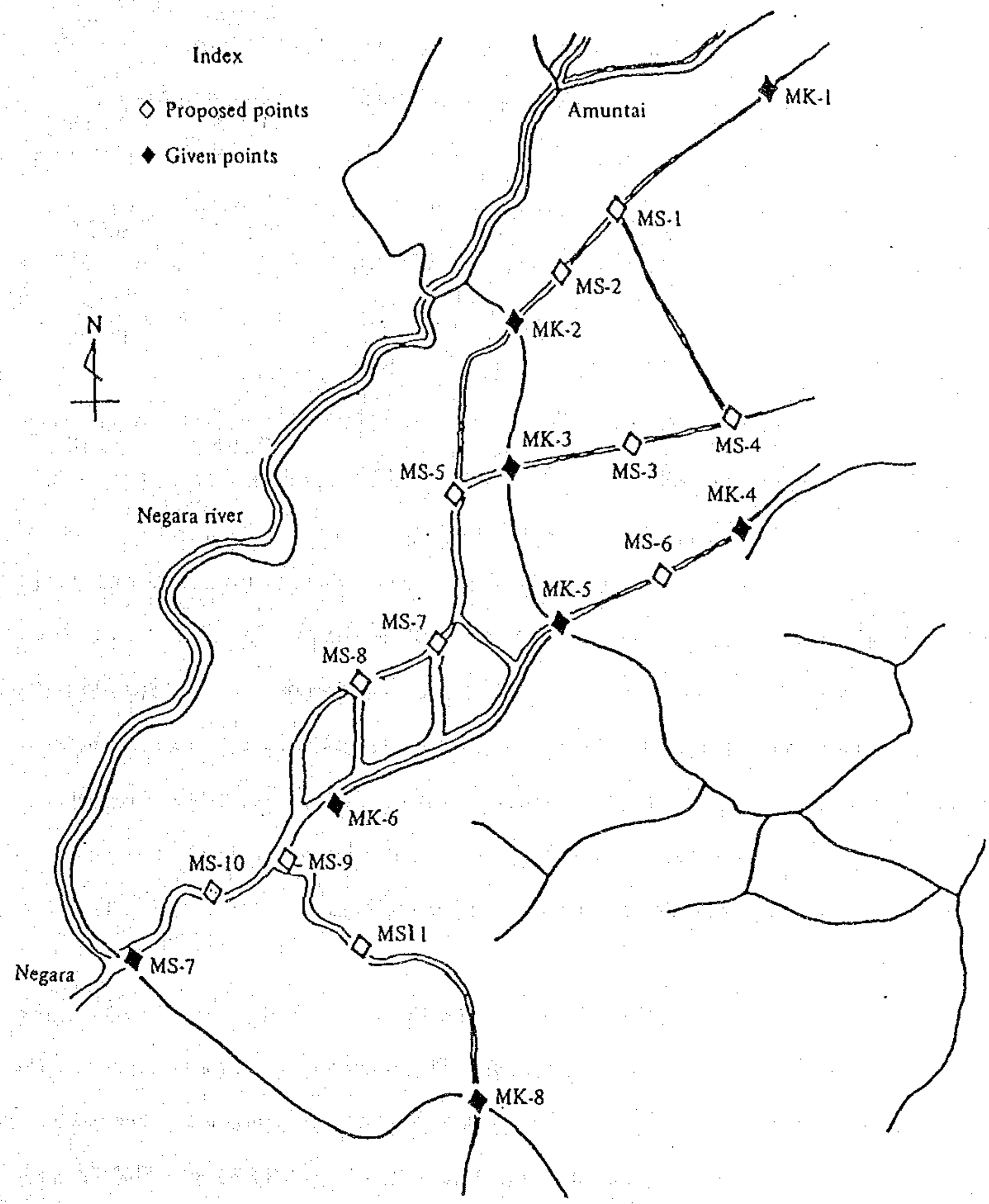
To establish vertical control point in swampy area, indirect levelling was carried out on 11 points by using river surface as medium. For this purpose, 8 points were established as given points starting from established bench marks by direct levelling. Location of points is shown in Fig. 4.5.

Points were grouped into three groups and observation was made for the following combination of given and new points. Each group was observed simultaneously 10 times every 20 minutes between 10 and 13 o'clock.

Group 1	given points:	MK-1, 2, 3
	new points :	MS-1, 2, 3, 4
Group 2	given points:	MK-3, 5, 6, 7
	new points :	MS-5, 7, 8, 9, 10
Group 3	given points:	MK-4, 5, 6, 7, 8
	new points :	MS-6, 9, 10, 11

Auto-level (Sokkisha B-2) and levelling staves were used for observation. The least reading unit was 1 cm. Some of new points were derived from different combination of given points. The discrepancies are as follows:

New point	Combination of given points	Height	Difference	Mean
		m	m	m
MS-1	MK-1, MK-2	2.829	0.04	2.81
	MK-1, MK-3	2.789		
MS-2	MK-1, MK-2	1.976	0.07	1.94
	MK-1, MK-3	1.910		



Group 1.	Given points	MK-1,2,3
	Proposed points	MS-1,2,3,4
Group 2.	Given points	MK-3,5,6,7
	Proposed points	MS-5,7,8,9,10
Group 3.	Given points	MK-4,5,6,7,8
	Proposed points	MS-6,9,10,11

Fig. 4.5 Location of Water Level Observation Points

MS-5	MK-3, MK-6	2.165	0.07	2.20
	MK-3, MK-7	2.239		
MS-7	MK-3, MK-6	0.585	0.13	0.65
	MK-3, MK-7	0.717		
MS-8	MK-3, MK-6	0.471	0.17	0.56
	MK-3, MK-7	0.642		
MS-9	MK-3, MK-7	0.624	0.15	0.55
	MK-6, MK-7	0.478		
MS-10	MK-3, MK-7	0.521	0.08	0.48
	MK-6, MK-7	0.446		

The standard deviation of the above discrepancies is 0.11m and the maximum value is less than 20cm even in the case where point distribution was not adequate considerdd from the direction of the river flow. Consequently, the results may be used as height control in aerial triangulation.

5. Field Identification (for photomap)

5-1 Summary

Collection and verification were executed for items to be represented on photomap, such as administrative names, geographical names (regional names, river names, etc.), names of important public buildings and road classification.

5-2 Administrative Names

It was decided to adopt Desa as the smallest administrative unit. Names were collected at the Kabupaten office and confirmed by checking with the results of interviews on the spot.

5-3 Geographical Names

For geographical names, we had to rely only on the results of hearings on the spot, because no materials could be collected as documents in advance. For rivers, especially small rivers, different names were given by each Desa where they flow. Consequently, it was decided to represent the name of such river at the central part of a map sheet in principle.

5-4 Building Names

Building name of principal public structures was collected and checked on the spot, such as of office of larger than Kecamatan, high school, hospital, police station, representative mosque.

5-5 Administrative Boundaries

Administrative boundaries of larger than Kecamatan were surveyed. However, they were shown only in boundary diagram (pumbagian daerah) in the marginal information, because it was difficult to put them in the map of 1/10,000 scale.

5-6 Road for Four-wheeled Vehicle

Classification of road for four-wheeled vehicle was left on the surveyor's judgement, because it was not always classified simply by width or pavement, but needed judgement according to the state of administration or season case by case.

6. Aerial Triangulation

6-1 Summary

Aerial triangulation was carried out analytically by block adjustment with independent models, using program package PAT-M 43. Factors of execution are as follows:

Work amount	:	28 courses, 376 models
Horizontal control points	:	25 points
Vertical control points	:	171 points
Photo scale	:	1/20,000
Focal length of camera	:	152mm
Instruments used		
pricking device	:	Kern PMG-2
Coordinate graph	:	Zeiss Jena Stecometer

Scope of the work is shown in Fig. 6.1, where principal point of photos, control points and tie points are also shown.

6-2 Work Flow

Work flow is as follows:

Confirmation of control points on photo and selection of pass points and tie points

↓

Pricking of pass points and tie points

↓

Measurement of photo coordinates of control points, pass points, tie points and corner indices of photo by stereo comparator

↓

Inner orientation

↓

Computation of model coordinates by relative orientation

Photo Scale 1:20,000

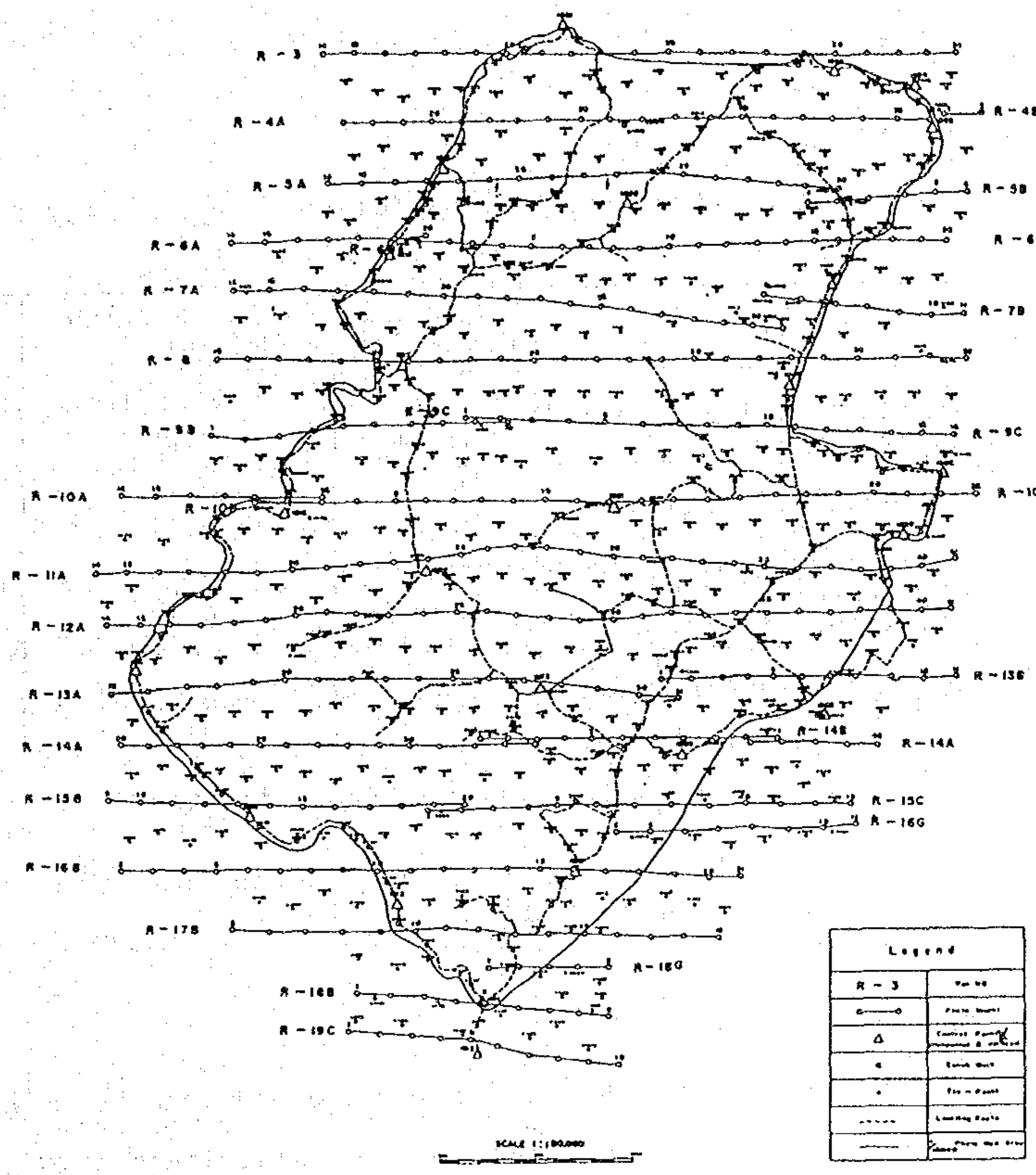


Fig. 6.1 Index Map for Aerial Triangulation

↓

Block adjustment by the method of independent models

↓

Computation of orientation elements of each model for plotter and rectifier

6-3 Results of Adjustment

Errors after adjustment are as follows:

	Standard deviation	Ratio to flight height (‰)	Maximum deviation
Residual of horizontal control points	0.89m	0.30	1.83m
Residual of vertical control points	0.37	0.12	1.41
Horizontal discrepancy of tie points	0.38	0.13	1.19
Vertical discrepancy of tie points	0.23	0.08	1.17

Tab. 6.1 Errors After Adjustment

7. Preparation of Controlled Mosaic

7-1 Rectification of Photos

1/10,000 scale controlled photos were prepared by using elements for rectification obtained from aerial triangulation. For rectification conventional method was used.

Number of photos	28 courses, 404 pieces
Instrument used	rectifier SEG-V (Carl Zeiss Jena)

7-2 Controlled Photo Mosaic

Pass points and corner indices of photo were plotted on the drawing sheet by automatic XY-plotter using their coordinates obtained from aerial triangulation. On the basis of the plotted sheet, controlled photos were mosaiced and cut in accordance with the proposed neat lines ready for the base of photomap.

Neat lines	:	60cm x 60cm
Number of sheets	:	48 sheets

8. Stereo-plotting

8-1 Summary

Stereo-plotting was carried out by using results of aerial triangulation and field identification. Map specifications were fixed after discussion with Indonesian side. Main specifications are as follows:

Plotting scale	:	1/10,000	
Plotting area	:	1,200km^2	
Projection	:	U.T.M. with grid lines of 1km	
Neat lines	:	6km x 6km (60cm x 60cm on the map)	
Contour interval	:	intermediate contour lines	5m
		index contour lines	25m
		supplementary contour lines	2.5m
Plotters used	:	Wild A-10, A8; Metrograph-E	

8-2 Plotted Elements

Main plotted elements were contour lines; in principle, 5m intermediate contour lines and 25m index contour lines were plotted. However, 2.5 m supplementary contour lines were also plotted, when it was needed for supplementation of topographic features.

In flat area where contouring was not found feasible, spot heights were measured to the unit of 10cm every 4cm x 4cm on the map, in principle. The density of spot height was increased in low swampy areas.

9. Geographical Survey

9-1 Landform Classification

9-1-1 Object

The term, landform classification, signifies that landforms are systematically classified by morphology, origin, time, material, etc. Results involved are expressed as a geomorphological landform classification map. Originally, the geomorphological landform classification map is prepared as the basis of a geomorphological study covering a certain region. More recently, however, it has been often utilized as the fundamental data for a regional development plan. The geomorphological landform classification map is effectively used in a variety of fields, e.g. an analysis of topographical factors associated with the growth of soil, a projection of river-flooding/inundation areas, etc.

The survey area comprises a delta composed mainly of the Negara River and medium- or small-sized rivers as its tributaries and a swamp extending behind the river. This region is mostly a low flat land with an altitude of 5 meters and below. A topographic map, therefore, would not allow us to easily know the geographical features of land. A more careful study of the low flat alluvial plain, however, permits us to discriminate a slightly high land, such as natural levee, from a slightly low land, such as an old river channel. The delta formed by the river through its fluvial action of the river, moreover, has a relatively higher altitude than the swamp remaining unfilled by the fluvial action.

Here, it was considered possible to know a relative height of land by classifying landform over the survey area. In addition, this may be replaced with such information concerning the relation between topography and water-surface, e.g. a pick-up of the areas likely to be submerged in flooding, a duration of such submerged period, etc.

9-1-2 Method

First of all, aerial photos were interpreted and landform boundaries were entered to prepare a landform classification reconnaissance map. Then, a minor-order levelling and boring were carried out upon the field survey to clarify the characteristics of each topographic feature aspect. Thus, a range of distribution was confirmed and corrected.

Micro-landform of the alluvial plain, moreover, is closely related to the land-use and features of vegetation. Our eyes were set on their distribution form, which was in turn utilized as auxiliary data for us to interpret aerial photos.

In view of the present survey, landforms were classified with emphasis placed on the relative height of each landform above the normal water level (which may well be considered as a water level in the dry season).

The landform types classified are as follows:

Delta : A low flat alluvial plain formed by the inundation and accumulation of the sand and mud transported by rivers, reaching nearly the reference level (which may well be considered as the swamp water level):

Once its growth has advanced to a certain level, the delta is subject to down-cutting by the river. This will result in a relative height between the general surface of the delta and the riverbed (or water-surface). Based on the relative height from the riverbed, the delta is here divided into two: one is the upper delta surface and the other is the lower delta surface.

Natural levee : A slightly high land formed through the accumulation of the sand and mud transported from upstreams:

Natural levee has been being used for villages and roads for long years, because it is slightly undulating and scarcely submerged in a flood.

Swamp : Swampy area formed behind such a slightly high land as natural levee, etc.:

R.J. Russel classified swamps into two: one is a back swamp where it is mainly covered by forest and the other a back marsh where it is mainly covered by grass field. These, however, are to be called the "swamp" on a blanket basis.

Old River Channel: An abandoned flow path formed as a result of flooding and inundation in the past:

Old river channels are universally distributed on such a landform as a delta, swamp, etc. They are shaped into a belt-like relative concave land.

Of those enumerated above, both natural levees and old river channels are distributed on either upper and lower deltas or swamps. They form slightly high and low lands, respectively.

Natural levee could be recognized as a slightly high land distributed like a belt or an island, by stereoscopical view of aerial photos. Such portions have villages and trees outstandingly grown, showing an obvious different landscape from the surroundings. An old river channel, moreover, is a continuance of the land which is slightly lower than the plain in the surroundings. Even if the surface water has ceased to flow with the river channel changed, the underground water continues on flowing. As compared with the surroundings, moreover, the underground water level is also high. So, an old river channel looks blackish in aerial photo. In this case, therefore, aerial photos could be interpreted, with attention paid to not only a relative height but also to a tone thereon.

9-1-3 Results

Fig. 9-1 shows a landform classification map of the survey area. Described herein are various characteristics by landform classified, including altitude, relative height above the normal water level, features of the surface geology and underground water level.

1) Upper Delta

This delta is situated in the foot of low relief mountains to the east of the survey area. And it is distributed along the upstream of the Batangalai and Barabai Rivers. The landform has a broad altitude of 7 - 13 meters. Some natural levees have an altitude reaching as high as 15 meters.

The upper delta is dissected in 5 - 7 meters by the present river channels. It normally has a relative height of 4 or 5 meters above the river water level in dry season (August). (See Fig. 9.2.) Therefore, there are very low possibilities of flooding and inundation even in rainy season when the water level rises.

The upper delta is located in outlet where a river flows out of a mountainous area into a deltaic plain. Originally, therefore, it occupies a topographic position that permits an alluvial fan to be formed. In the upstreams of the mountainous area, however, rocks have been mechanically weathered under the highly humid tropical environments. As a result, the land is covered with a thick laterite soil and few conglomerates are produced. And only finely grained substances are carried into the river.

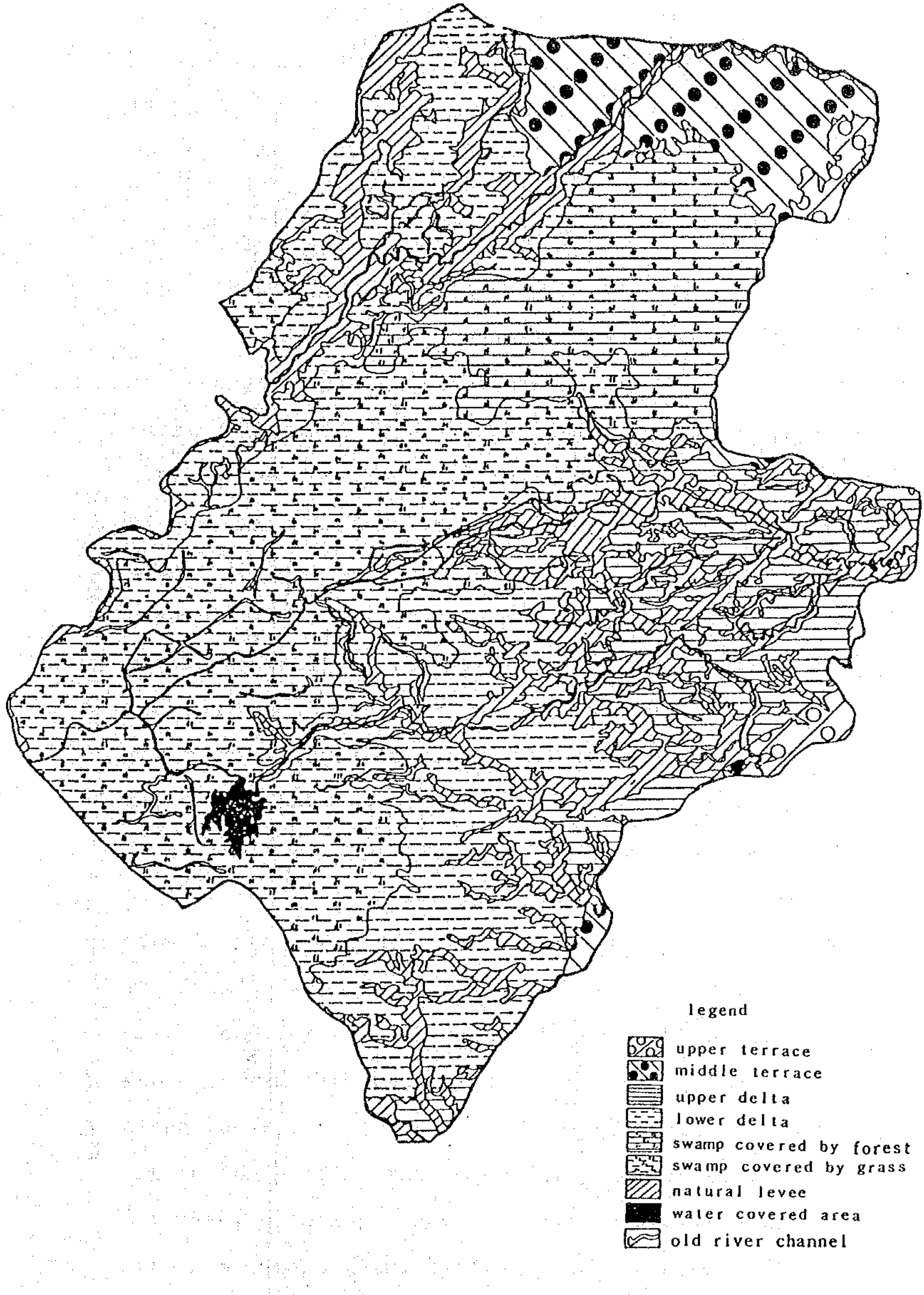


Fig. 9.1 Landform Classification Map

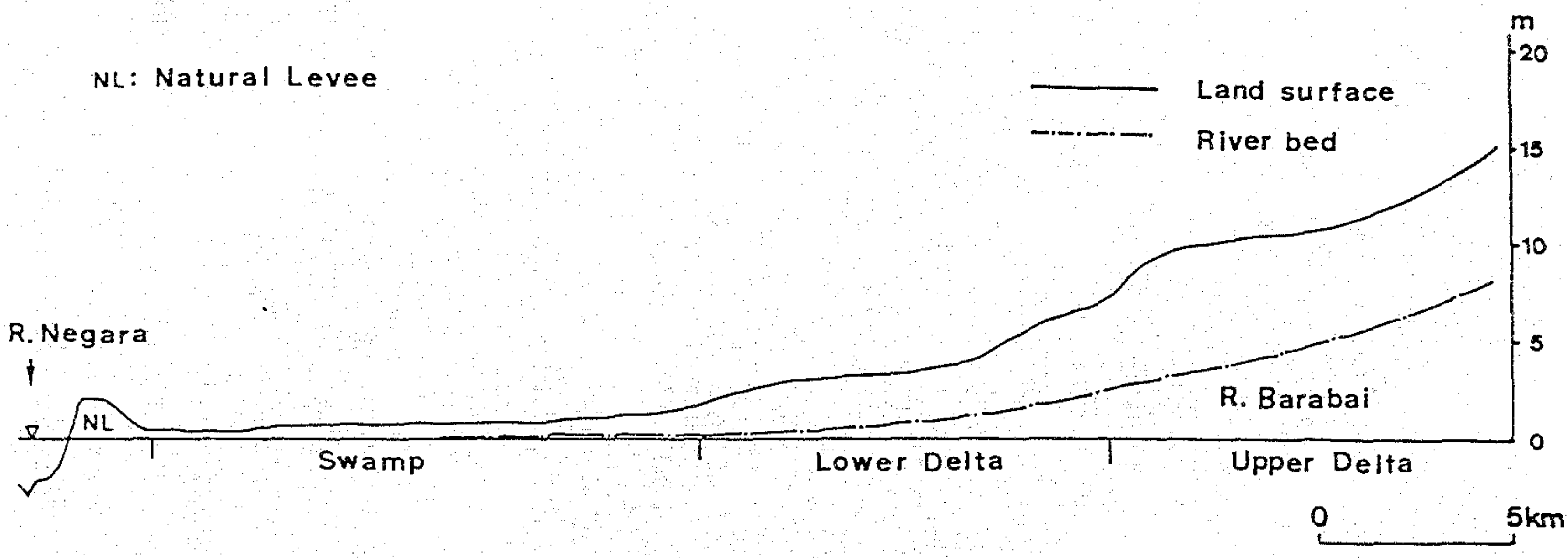


Fig. 9.2 Landform Cross Section along the Barabai River

Thus, mainly silt and clay have accumulated from the outlet of the mountain to form the delta. Its surface gradient reaches 0.8 $^{o}/_{oo}$, which is the steepest in the survey area. (See Fig. 9.2.)

2) Lower Delta

The area of the lower delta is broader in front of the upper delta (downstreams) and slender along the Negara River. It generally has an altitude of 3 - 7 meters and the surface gradient is 0.4 $^{o}/_{oo}$, which is more gentle than that of the upper delta. The lower delta which broadly extends towards downstreams of the Batangalai and Barabai Rivers is dissected 3 - 4 meters by the present river channels. Besides, a relative height of approximately 2 meters prevails in relation to the water level in dry season (August). (See Fig. 9.2.) Coupled with a rise of river water level in rainy season, therefore, some areas are widely submerged. Nevertheless, the flooding period is as short as approximately one week, from the interview on the spot. Given in Fig. 9.3 is a landform cross section on the lower delta of the Batangalai and Barabai Rivers from a swamp to the north of the survey area.

The materials composing the lower delta could be known to some extent, based on the boring data obtained along the Batangalai River as shown in Fig. 9.4. According to these data, the lower delta has approximately 3 meter thick outermost faces of silt and clay mixed with rotten plants (organics) from place to place. At the part lower than the stratum, however, sand and silt are

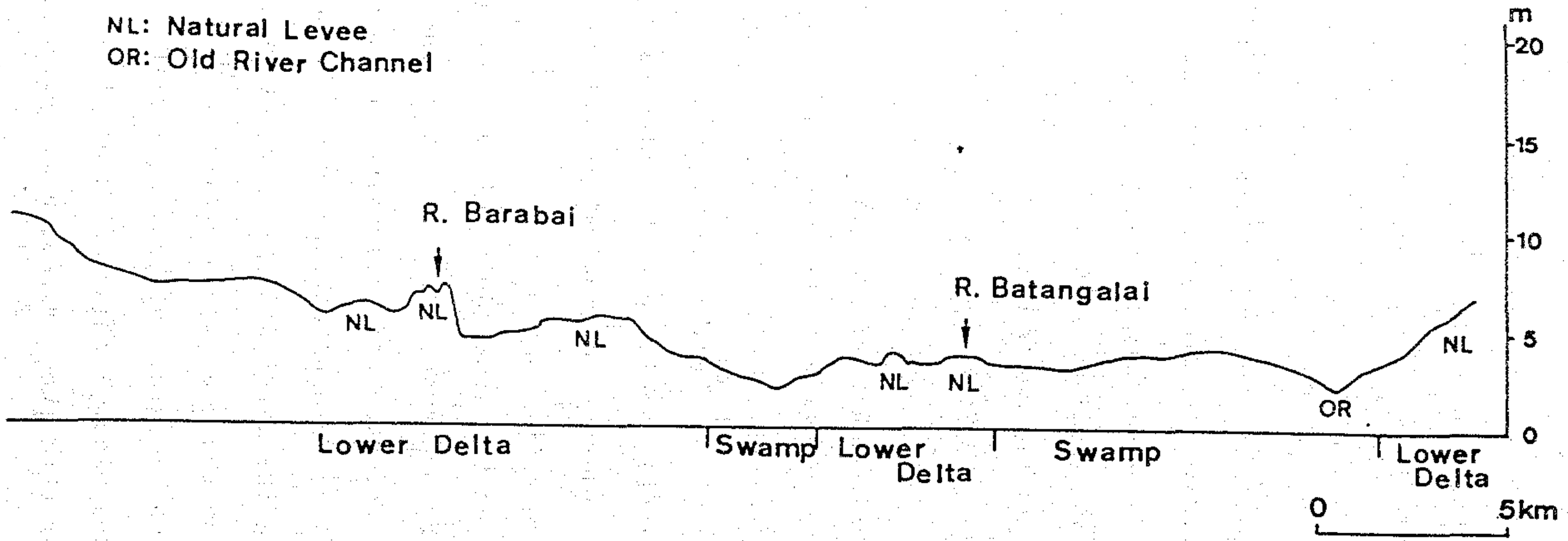


Fig. 9.3 Landform Cross Section on the Lower Delta

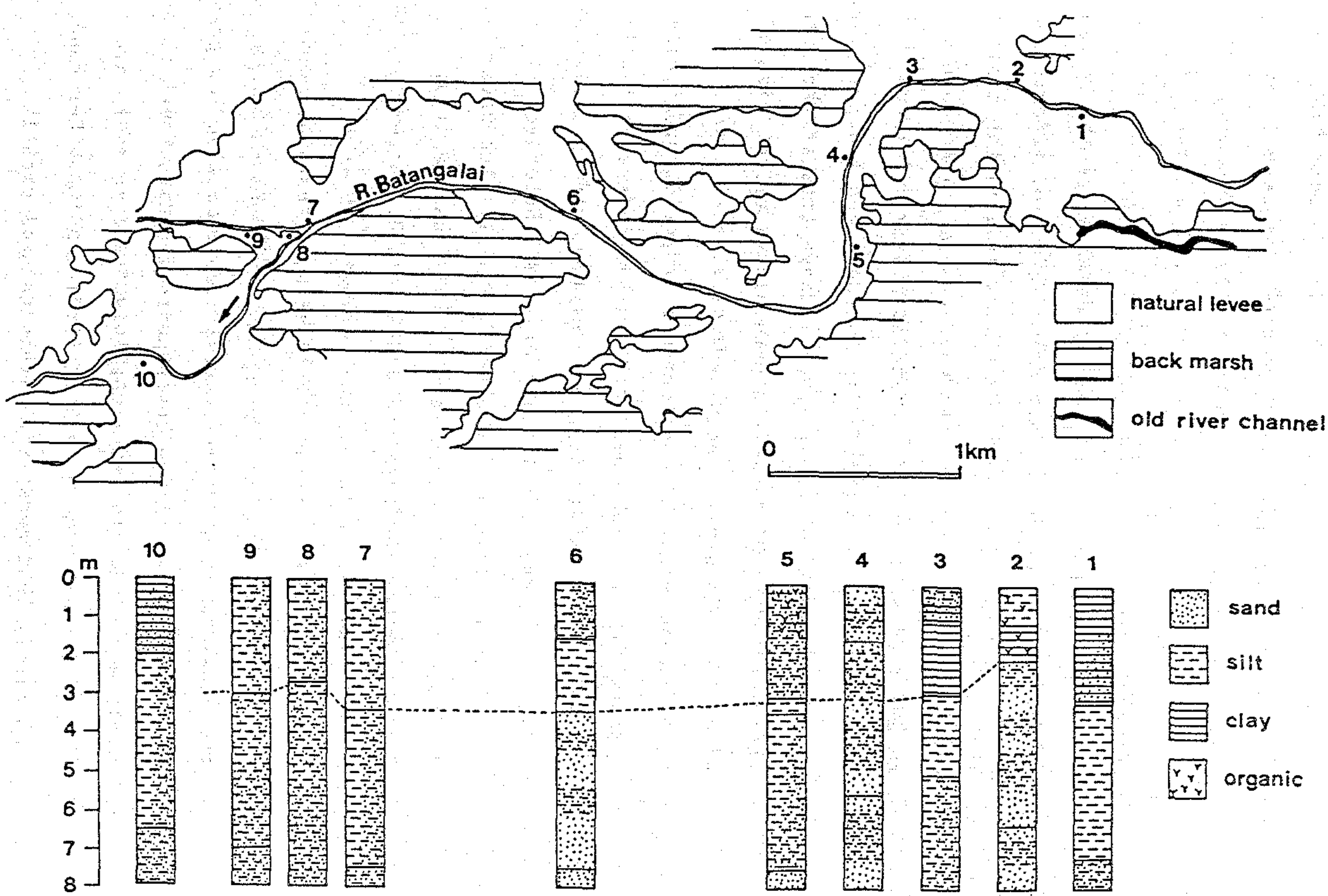


Fig. 9.4 Boring Columns along the Batangalai River

alternately stratified or a sandy silt is remarkably seen. This demonstrates that sand particles are seldom carried as the substances accumulated recently in flooding.

3) Swamp

The swamp is situated between the delta along the Negara River and another delta formed by a group of tributaries which flow down from the mountainous area in the east. It occupies a large area in the survey area. The swamp has an altitude of 1 - 3 meters and is poorly undulated. There is little relative height between the landform (surface) and the river water level. Many parts of the swamp, therefore, will be submerged even with a slight rise of water level in dry season.

The swamp may be considered as a portion remaining not backfilled. In other words, it is an area not affected by the river's flooding/accumulation action unlike a delta. From an overall point of view, therefore, it is a tray-like depression. Once an abnormally high water level has been experienced, therefore, it is assumed that the both water covered area and depth will be large and that flooding will last for a long period.

In the north of the survey area, forests are distributed over the swamp. In the middle and southern parts, on the other hand, the swamp is widely covered with low grass. The former has no micro-topographic features, such as natural levees and old river channels. And no parts are submerged in rainy season. The latter, on the other hand, has highly continuous old river channels closely distributed. Along these slightly low areas, many portions are widely submerged in rainy season.

4) Natural Levee

Natural levees are distributed over the surface of each landform type, such as upper and lower deltas and swamp. And they form a land slightly higher by approximately 0.5 - 1 meter than the surroundings. The natural levee is generally considered as the slightly high land formed as a result of accumulating along a river the sand and mud transported by the river flooded. These natural levees show a higher distribution density in the upper delta and tend to have a lower distribution density in the swamp. This is because the former receives a remarkable flooding/ accumulation action of the river while the latter does not receive it sufficiently.

Fig. 9.5 shows a topographic cross-section of the natural levees distributed on the upper delta, including the results of observing the surface soil with boring stick. Natural levees have a relative height of approximately 50cm as compared with that to the west of the upper delta on the back. And it has a relative height of approximately 1 meter above old river channel. The surface geology has a soil composed of remarkable fine-grained materials, with silt and clay mainly contained. Analysis of the particle size of each deposit, moreover, has proved that every natural levee has a higher content of fine sand as compared with any other landform units. This demonstrates that natural levees were produced as a result of

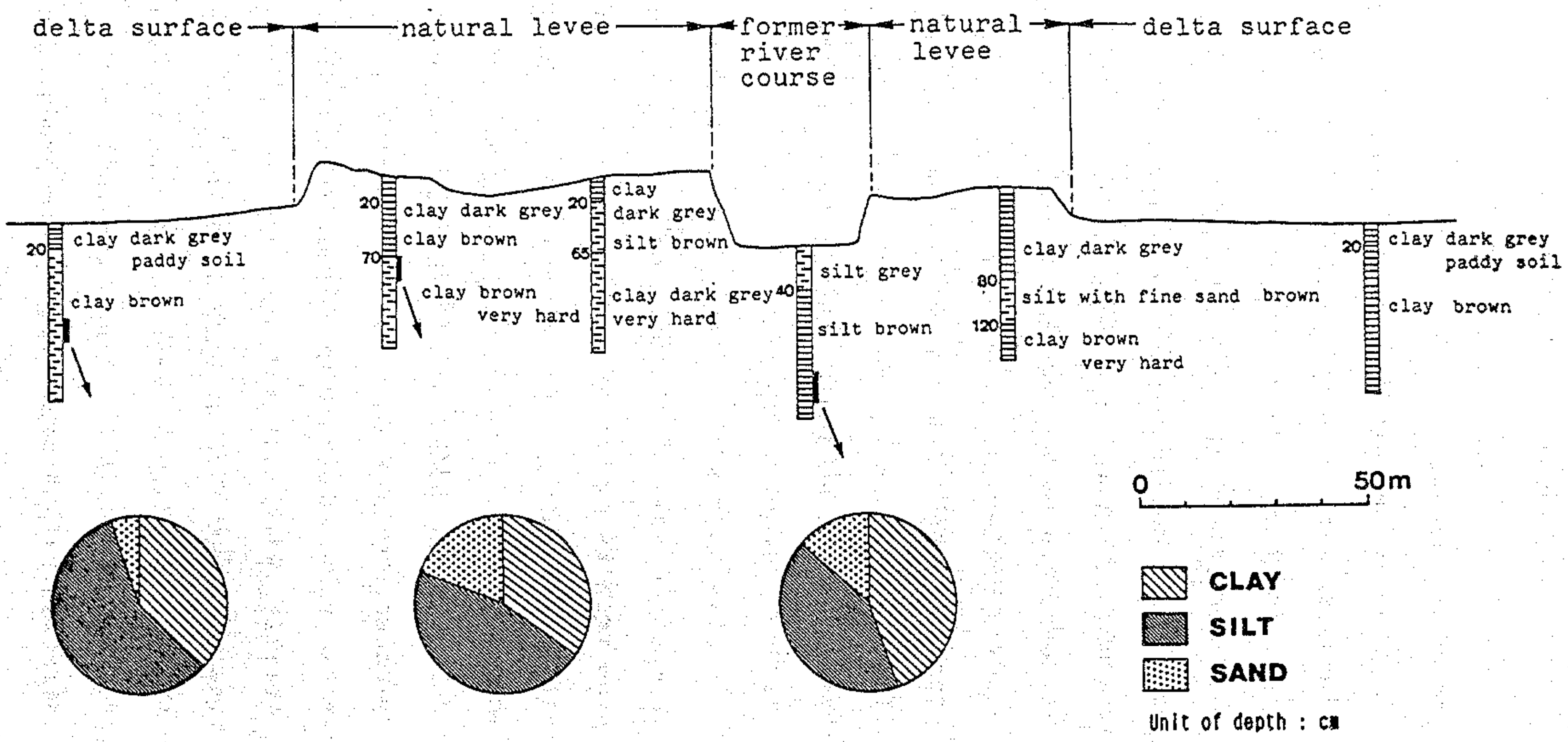


Fig. 9.5 Landform Cross Section and Surface Deposits on the Upper Delta Surface

the river's flooding/accumulation.

In swamp, on the other hand, natural levees have very poorly developed. Along the Batangalai River, a few small-sized ones could be seen only. They are a high portion with a relative height of less than 1 meter free from being submerged even in rainy season. At these portions, villages have been located for long years.

5) Old River Channel

It is in the area along tributaries, such as the Batagalai and the Barabai Rivers, etc. that old river channels are closely distributed. Not so many old river channels, however, could be seen along the Negara River.

Features of old river channels in the survey area could be divided roughly into two: one is the belt-like concave land forming an approximately 1 meter small scarp observed in the field survey, showing a conspicuous relative height as gathered from stereoscopic observation of aerial photos. These old river channels are highly continuous generally, along which natural levees are also distributed. The old river channels drawn on Fig. 9.1 "Landform Classification Map" are of such type as mentioned above.

The other is a pickup of the blackish portion from a continuous tone in aerial photos. Its relative height could not be seen from the photo-interpretation. Even the field survey could not allow us to recognize an express topographic boundary, showing a relative height of approximately 50cm at the most. Besides, these old river channels are poorly continuous. Such differences of features between the two as mentioned above are considered reflecting the new or old times when such old river channels were paths of flow or the duration of such times.

9-2 Water Covered Area

9-2-1 Object

Water covered areas in dry and rainy seasons are grasped through aerial photo-interpretation and field survey to confirm how water covered condition changes between dry and rainy seasons, which could not be expressed with contour lines.

9-2-2 Method

1) Water covered area in rainy season:
   To grasp how the swamp is covered by water in rainy season, a field survey was conducted and basic data were obtained to interpret aerial photos. Based on the interpretation key, the aerial photos taken in rainy season were interpreted to extract the areas covered by water in rainy season. After then, they were transcribed on the compilation manuscript. These works, however, were done in Indonesia when the survey team visited there, because those photos could not be taken out of Indonesia.
2) Water covered area in dry season:
   To grasp how the swamp is covered by water in dry season, the aerial photos taken in dry season were interpreted prior to the field survey, based on the interpretation key referred to in 1) above. And the areas covered by water

in dry season were delimited. In the field, a boat and other means were used to confirm and correct mainly those portions which could not be clearly interpreted. Thus, the areas covered by water in dry season were transcribed on a photomap to a scale of 1/10,000.

9-2-3 Results

The areas covered by water in dry and rainy seasons are as shown in Fig. 9-6, respectively. The areas covered by water in dry season are distributed a little collectively in the southwest of Amuntai and around the Lake of Bankau to the south of the survey area. In addition, small-sized ones are distributed in old river channels and slightly low land of the back swamp.

The areas covered by water in rainy season are widely distributed mainly in the swamp to the west of the survey area. Its total area covers 84.3km^2. Besides, all the old river channels and slightly low lands in the swamp are submerged and the floating grasses, mainly <Eichhornia crassipes> [Ilung]*, are growing closely. Over the upper and lower deltas where Barabai and Kandagan are located, a paddy field is extending without any water covered areas seen there.

Next,in order to study whether the distribution of water covered areasfor the current year is normal or not, were computed the mean values and standard deviations of the monthly rainfall in March at two spots (Mangangan and Tangga) for the latest ten years. (Tab. 9.1) According to these data, both points showed a monthly rainfall in March at a level nearly to the mean value.

Consequently, the distribution of water covered areas is assumed to remain on the mean level. (paragraph 16-1)

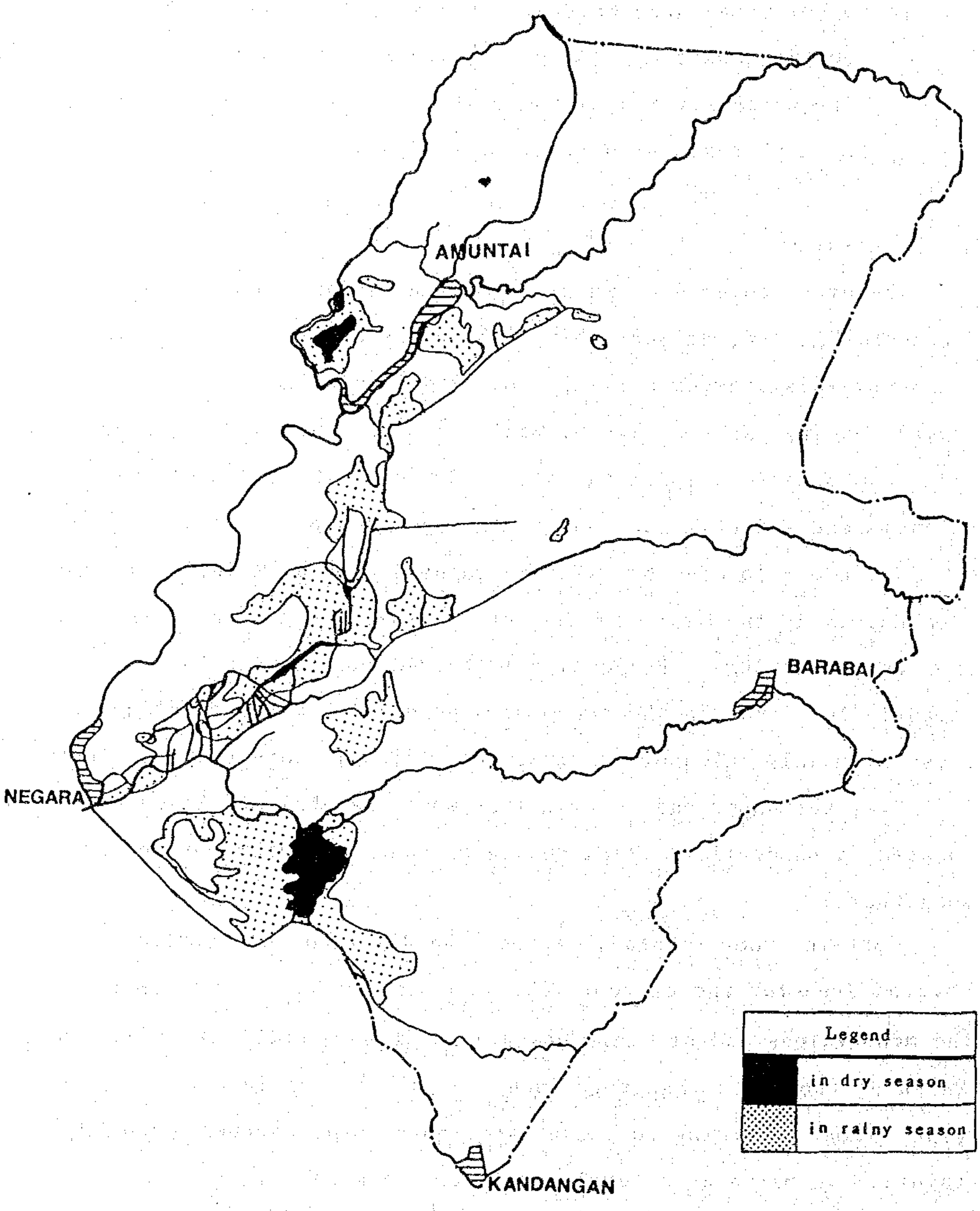


Fig. 9.6 Distribution of Water Covered Area

(Unit: mm)

Year / Site of observation	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Mean	Standard diviation
KANDANGAN	323.5	286.5	394	320	256	192	348	44	352	226	274.2	96.4
TANGGA	—	322.5	31.2	174	178	250	386	116	191	330	219.9	106.6

Tab. 9.1 Monthly Rainfall in March

* < > represents a botanical name while [ ] indicates the name used in the Province of South Kalimantan. [7, 8]

9-3 Land-use and Vegetation

9-3-1 Object

Paddy field farming in the survey area varies significantly between dry and rainy seasons. In the delta with a slightly high altitude, paddy fields are cultivated in rainy season. In the swampy area which is covered by water in rainy season, on the other hand, paddy fields are cultivated in dry season. Such a change in land-use between dry and rainy seasons may be considered representing a relation with water. The vegetation, moreover, has its foundation defined by micro-landforms (water situation). With such situations in the background, the survey is to grasp the land-use and the features of vegetation, aiming at the obtainment of supplementary data indicated on a topographic map (contour lines), though associated with a relative height.

9-3-2 Method

1) Land-use in rainy season:
   To grasp the paddy fields cultivated in rainy season, a field survey was carried out in that season to obtain the fundamental data for interpretation of aerial photos. Based on the interpretation key, the aerial photos taken in rainy season are used to extract the paddy fields

cultivated. After then, the data so obtained were illustrated on a photomap at a scale of 1/10,000.

2) Land-use and vegetation in dry season

To grasp the land-use and distribution of vegetation in dry season, the aerial photos taken in dry season were used to interpret and delimit the land-use and vegetation prior to the field survey.

In the field, several typical survey points were provided in consideration of the topography, vegetation and water covered areas in rainy season so as to investigate the vegetation within a range of such survey points. At the same time, relative heightswere determined between sections within a range of the survey points. For land-use, moreover, interview was locally carried out to gather the information relating to the paddy field cultivating period, etc. For those portions which could not be clarified while interpreting aerial photos, among others, boats, motor vehicles, etc. were used to confirm and correct the results of photo-interpretation in the field.

The field survey findings and aerial photos were re-interpreted and the land-use/vegetation were inscribed on a photomap of a scale of 1/10,000, based on the classification specified below.

Residential area	(daerah pemukiman)
Paddy field in dry season	(persawahan di musim kemarau)
Paddy field in rainy season	(persawahan di musim penghujan)

Field	(ladang)
Burnt field	(perladangan berpindah)
Pasture	(padang rumput)
Fallow paddy field	(Tegalan)
Forest	(hutan tinggi)
Shrub	(hutan rendah)
Tall humidiherbosa	(padang rumput tinggi)
Short humidiherbosa	(padang rumput rendah)
Dry meadow	(alang-alang)
Floating grass	(rumput air)
Water covered area	(permukaan air)

9-3-3 Results

Land-use and vegetation areas by item are as shown in Tab. 9.2.

Item	Area (km^2)	Item	Area (km^2)
Residential area	18.8	Forest	286.8
Paddy field (in dry season)	159.6	Shrub	50.3
Paddy field (in rainy season)	313.6	Tall humidiherbosa	36.3
		Short humidiherbosa	193.1
Field	8.2	Dry meadow	6.8
Burnt field	2.4	Floating grass	7.3
Pasture	60.6	Water covered area (dry season)	15.4
Fallow paddy field	55.6		

Tab. 9.2 Land-use and Vegetation Areas by Item

The land-use in the survey area corresponds well to the micro-topographic terrain. Their relations are as roughly shown in Fig. 9.7.

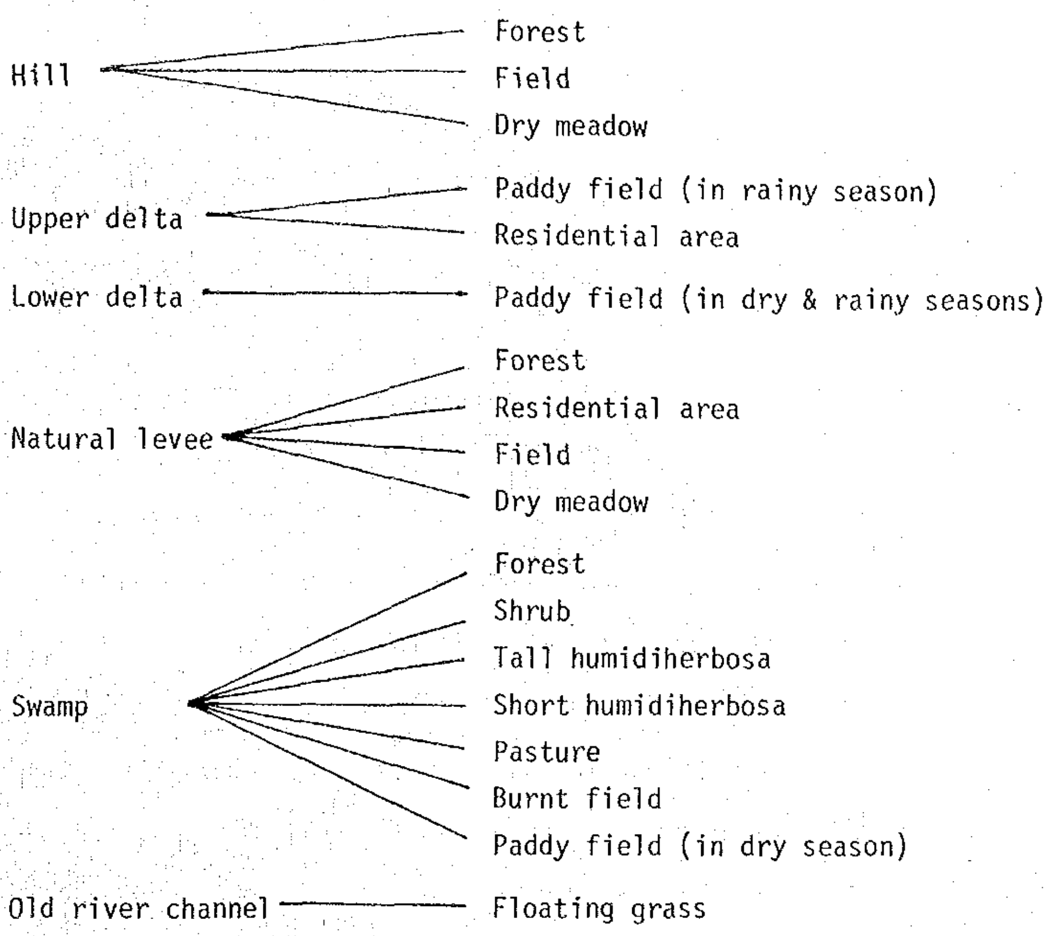


Fig. 9.7 Landform Classification vs. Land-use/Vegetation

Land-use and vegetation are mainly distributed as follows:

1) Paddy Field

Paddy fields occupy approximately 40% of the survey area as a whole and may be divided, if roughly classified, into those cultivated in dry and rainy seasons. (See Fig. 9.8.) The paddy fields cultivated in rainy season are distributed mainly in the upper and lower deltas with a slightly high altitude. The distribution is in full scale to the southeast of the survey area. Besides, they are also distributed to the north, too. The paddy field area

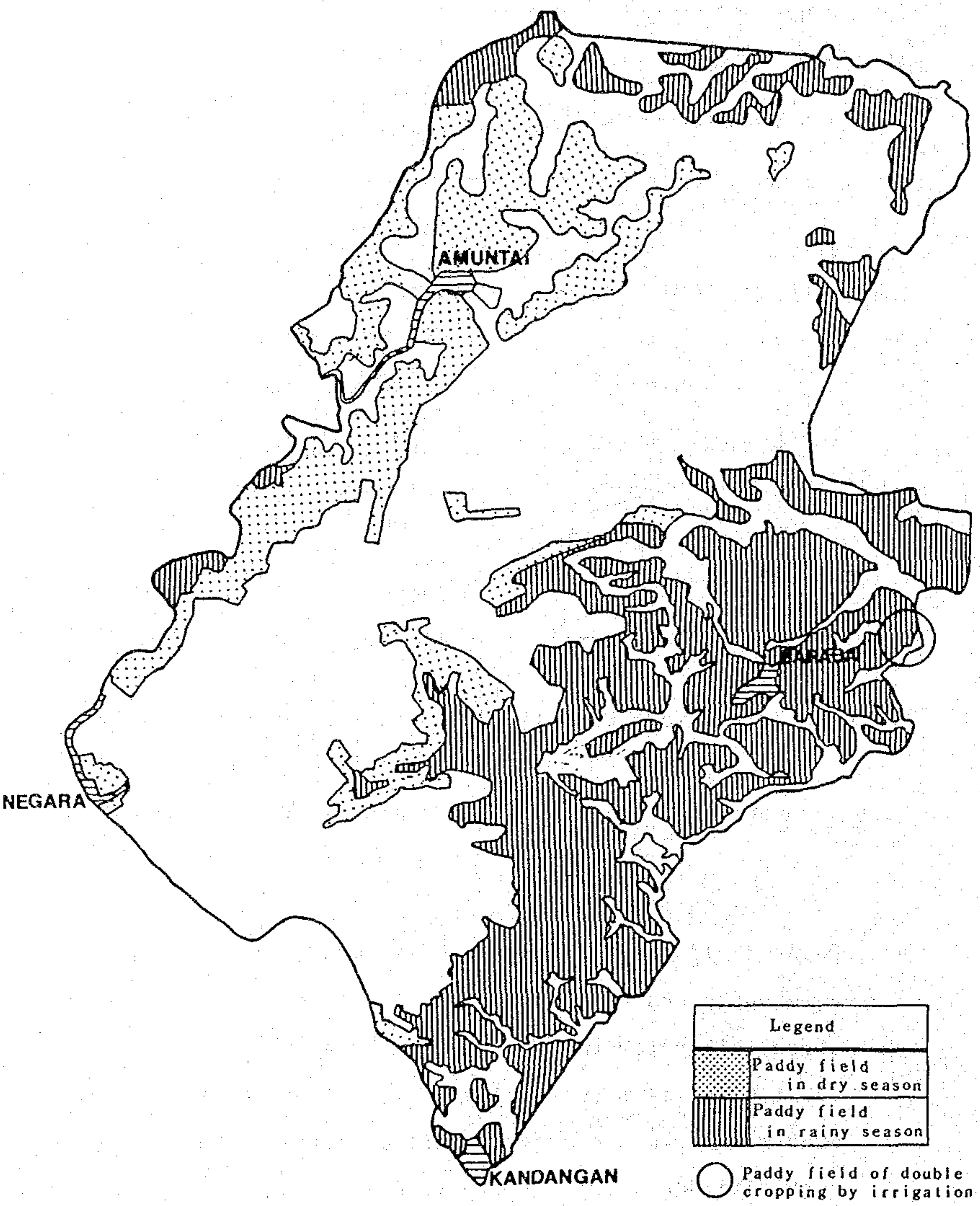


Fig. 9.8 Distribution of Paddy Field

cultivated in rainy season is located in the area with a slightly high altitude. In dry season, it is utilized as a pasture for livestock.

The paddy fields cultivated in dry season are distributed in the swampy area and in the lower delta along the Negara River. The paddy fields in these areas are submerged or turn out a muddy swamp in rainy season and can be cultivated in dry season only.

The areas in which double cropping is available, on the other hand, could be seen to the east of Barabai and partially in the lower delta. Irrigation has enabled the area to the east of Barabai to farm in dry season. The paddy fields which could be seen partially in the lower delta are blessed with the natural landforms which permit double cropping. These double cropping fields, however, have a very little area and are included in the paddy fields cultivated in rainy season, accordingly, as seen in the photo.

According to the interview, meanwhile, there are two types of rice, i.e. [Padi biasa] and [Padi unggul]. The former requires 5 - 6 months and the latter requires approximately 3 months for harvesting.

2) Field

Fields are distributed in a very small area, which occupies less than 1% only. They exist on those natural levees and hills which will not be submerged even in rainy season. Cultivated products are mainly tuber [Vbikayu], maize [Jagung], squash [Waluh], peanut [kacang], pineapple

[Neras] and sugar cane [Tebu].

3) Burnt Field

Burnt fields are distributed in a very small area, which occupies less than 1% only. To make a burnt field, a low tree <Mimosa pigra L.> [Jepung] belonging to legume is fired and twigs are taken as a fuel. And the field so made is leveled. After then, it is used for farming. Rice cropping is also performed in some burnt fields.

4) Pasture

The pasture occupies an area percentage of approximately 5%, in which buffaloes are grazed. Pastures are distributed in the swampy area extending from Amuntai to Negara along the Negara River. Most of these areas are submerged in rainy season. Short humidiherbosa is extending over a wide area and buffaloes are flocking together, giving a view peculiar to the swamp.

5) Fallow Paddy Field

A paddy field was cultivated once but abandoned later for a certain reason, occupying an area percentage of approximately 5%. Fallow paddy fields could be seen in the lower delta and in the swampy area.

6) Forest

Forests occupy an area percentage of approximately 24% and are widely distributed on natural levees and hills. In addition, they are also distributed in the area with a slightly high altitude in the swamp. (See Fig. 9.9.) Forests could be broken down mainly into rubber plantations, palm trees and natural forests, all of which could be seen in the area with a slightly high altitude. In other words, they are so located as not to be submerged even in rainy season.

On natural levees, palm trees are mainly growing while rubber plantations prevail on hills and in the lower delta. Of the swampy area, the portions with a slightly high altitude mainly have natural forests. Thus, a view of forests is an important key to interpreting the landform classification. Grasping a forests-distributed area, though relative, moreover, will permit us to find out the areas with a slightly high altitude.

Main forests are described below by type.

① Palm Trees

Palm trees are distributed on the natural levees and in the upper delta of the survey area. Coconut palm is planted and cultivated around residential areas and on the borders of paddy fields. Residential areas and banana plantations could be seen in an understory of palm trees. They constitute a main landscape in this area, together with paddy fields.

Palm trees are planted and cultivated on natural levees, having their ground height dependent upon the size of a natural levee. Palm tree cultivating areas, however, are not submerged even in rainy season. In addition to palm trees, a variety of fruit trees are

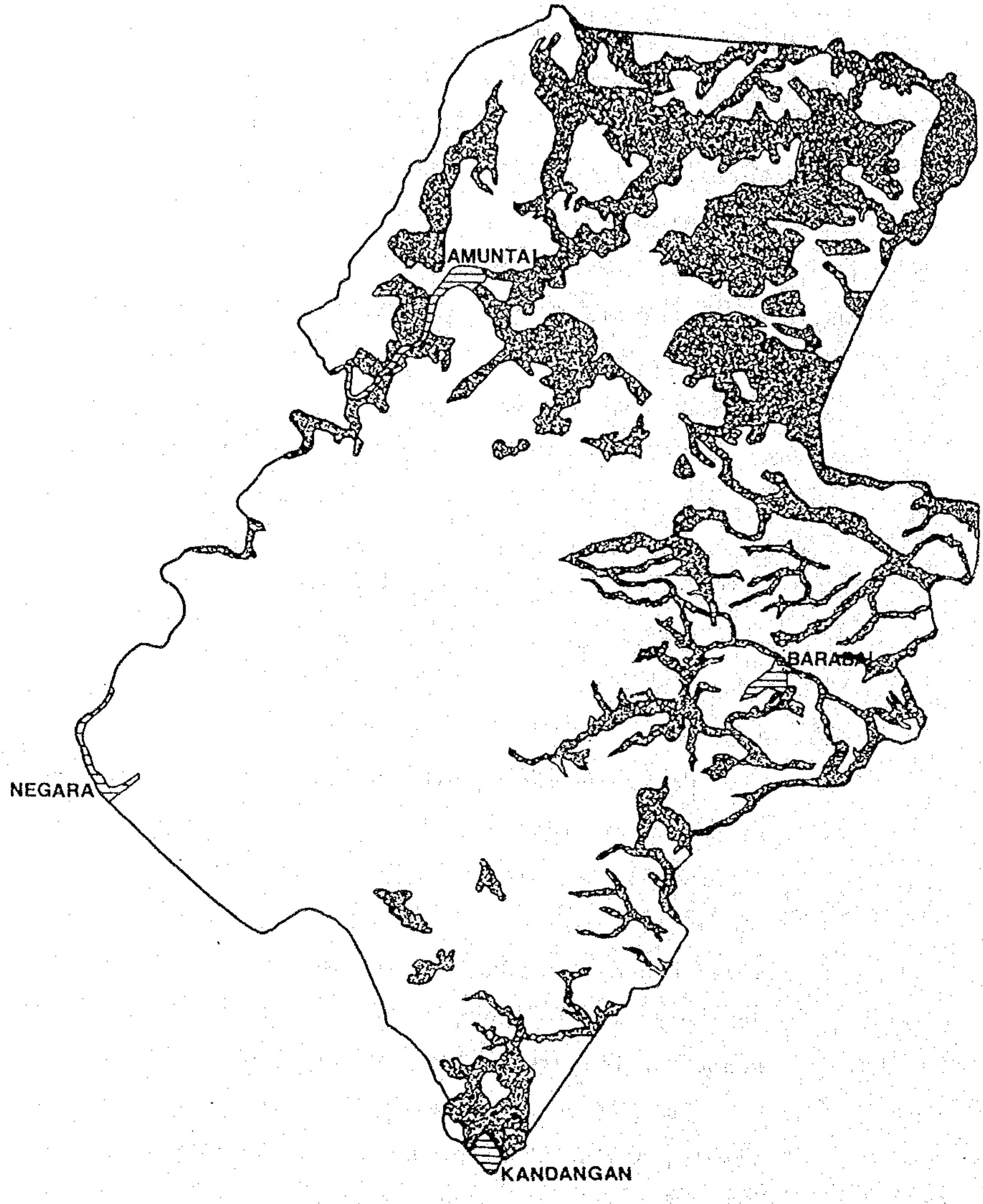


Fig. 9.9 Distribution of Forest

planted and cultivated on natural levees, mainly including the followings:

banana [Pisang], [Binjai], [Ketapi], [Nangka], [Langsat], [Ramania], [Ampelam], [Kayusapat], coffee [Kopi].

② Rubber Plantation

Rubber plantations are distributed mainly in the lower delta and on hills to the north of the survey area. In addition, they could be seen on some natural levees. Rubber (gum kino) [Pohon karet] mostly has a tree height of approximately 15 meters. In an understory of the rubber plantations in the lower delta and on hills, shrubs grow together while fruit trees, such as banana, are planted and cultivated in an understory on natural levees.

③ Natural Forests

Natural forests are distributed in the area with a slightly high altitude out of the swampy area. And they could be seen to the north of the survey area. These forests mainly comprise <Planchonella obovata Pierre> [Kayu sapat], <Melalevca Leucadendrom L.t.> [Galam] and <Nauclea subdita Merr.> [Bangkal]. These forests are distributed in the area with a slightly high altitude, though relative.

A relative height of approximately 20 - 100cm in comparison with the surroundings was obtained in the field survey. (See Fig. 9.10.)

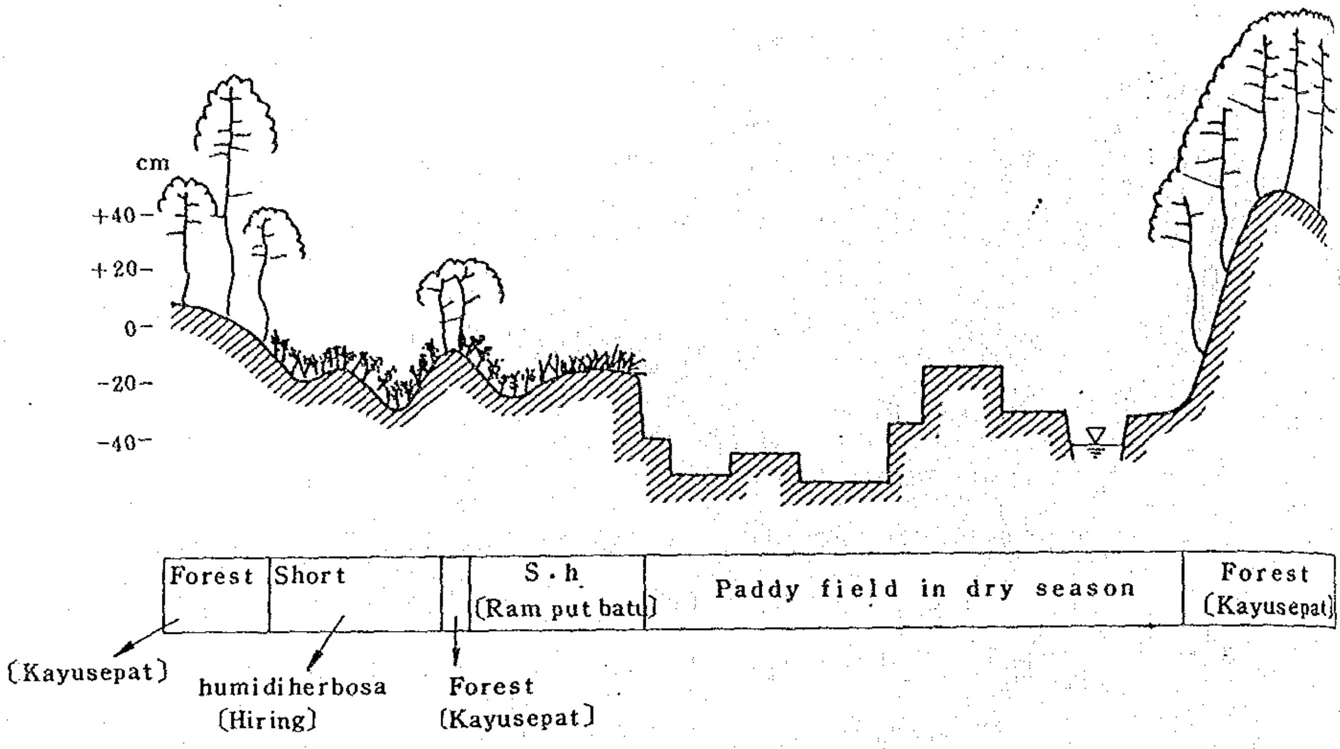


Fig. 9.10 (a) Cross-sectional View of Vegetation (1)

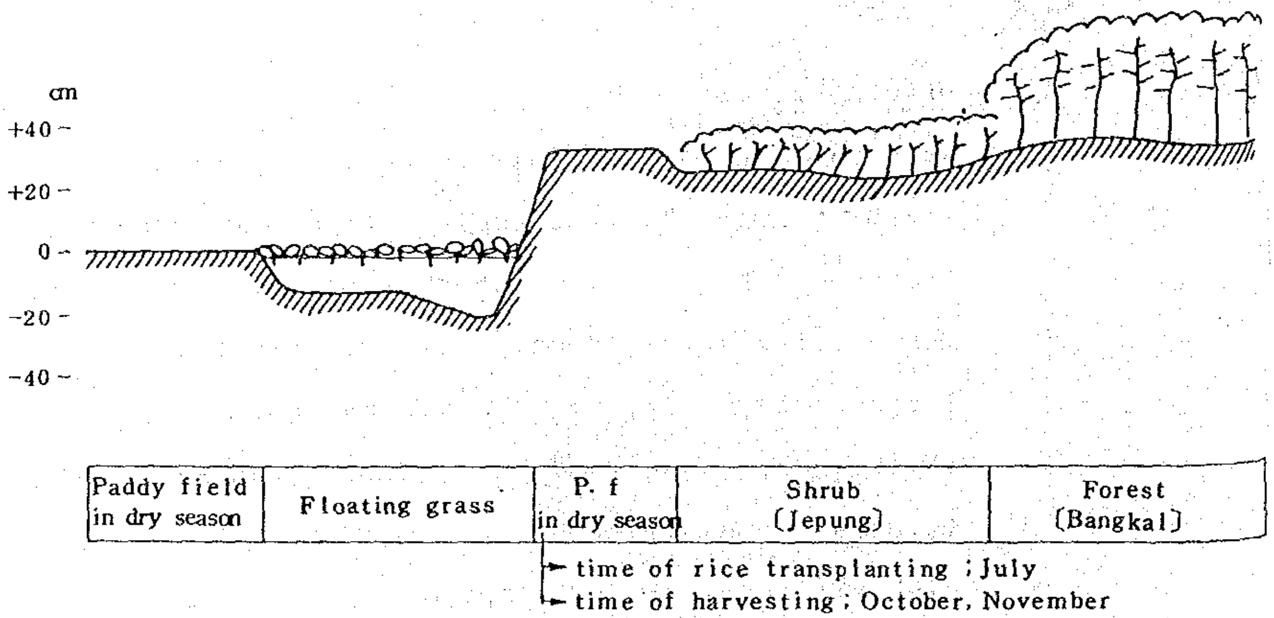


Fig. 9.10 (b) Cross-sectional View of Vegetation (2)

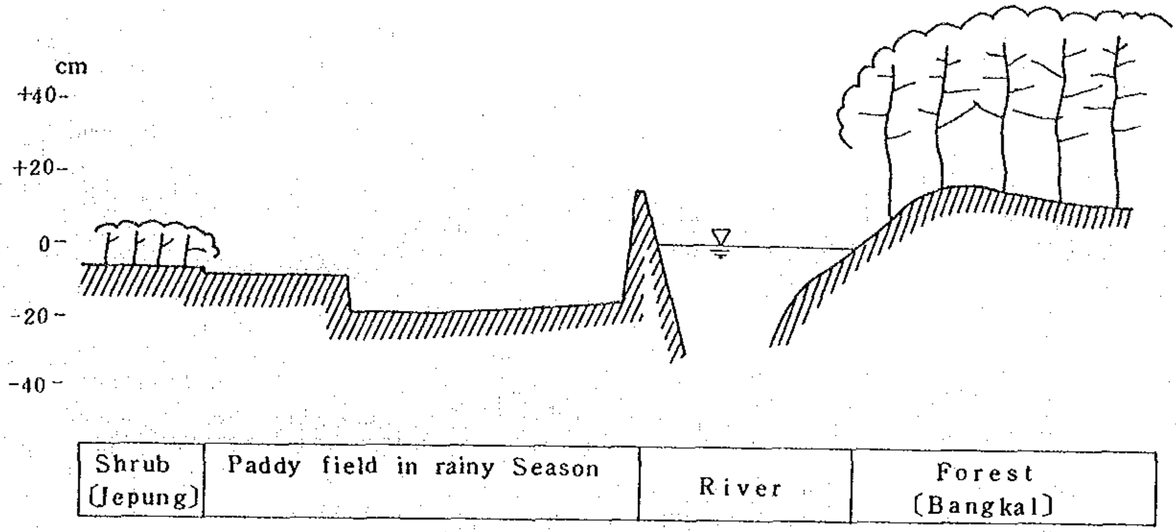


Fig. 9.10 (c) Cross-sectional View of Vegetation (3)

7) Shrub

Shrub occupies an area percentage of approximately 4% and is distributed in the swampy area to the west of the survey area. (See Fig. 9.11.) This is a simple community of approximately 2 meter high <Mimosa pigra L.> [Jepung], a series of legminous shrubs, which closely grow together. These shrubs constitute a main landscape of the swampy area.

Shrubs have a relatively large area in the flat swamp and a relative height from the vegetation (grass field) in the surroundings not so clear as that owned by forests. Nevertheless, they have a relative height of approximately 10 - 30cm. (See Fig. 9.12.) In rainy season, shrubs are submerged in some areas. Mostly, however, they are not submerged but located often on the soil which will be hard on the surface in dry season.

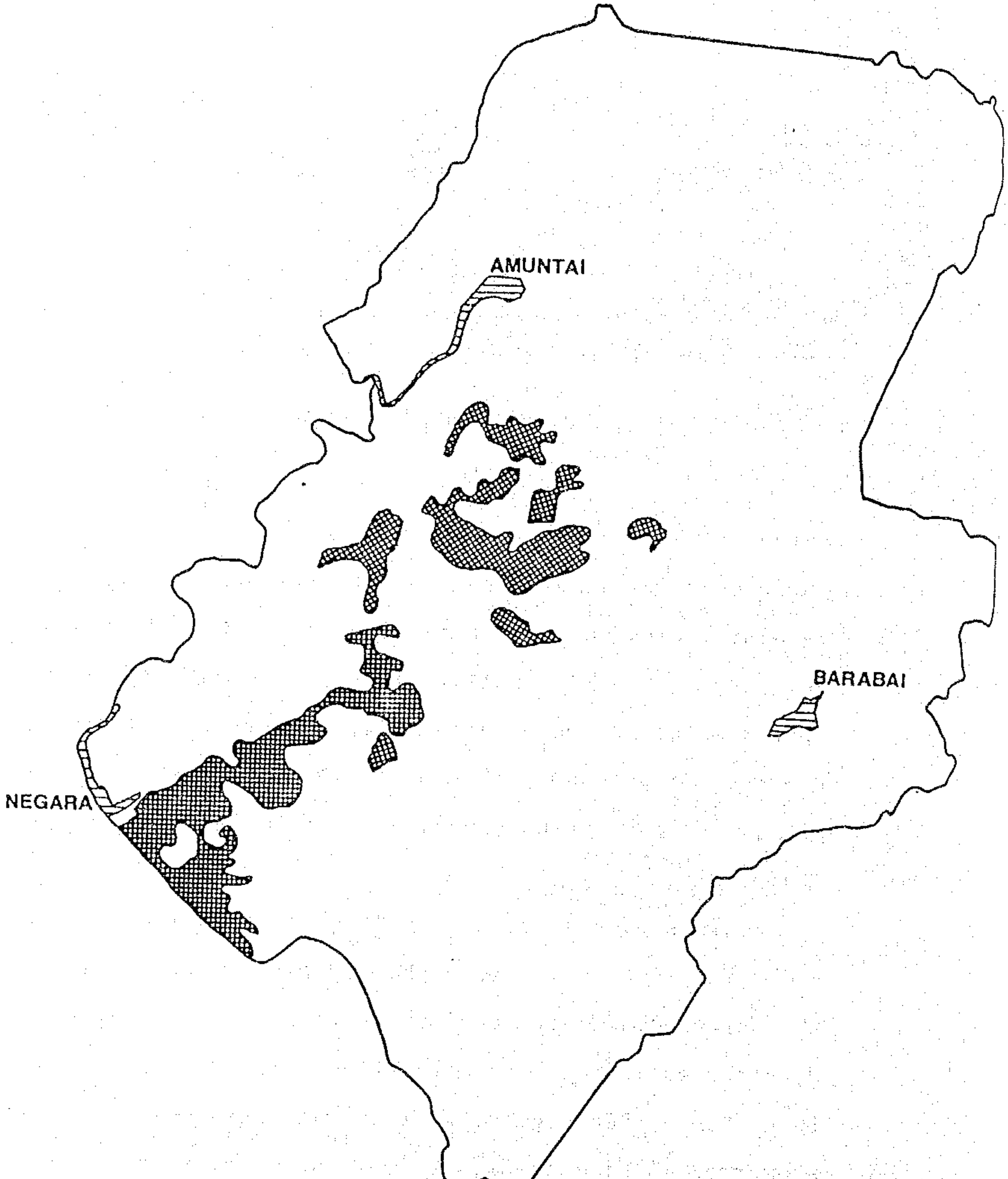


Fig. 9.11 Distribution of Shrub

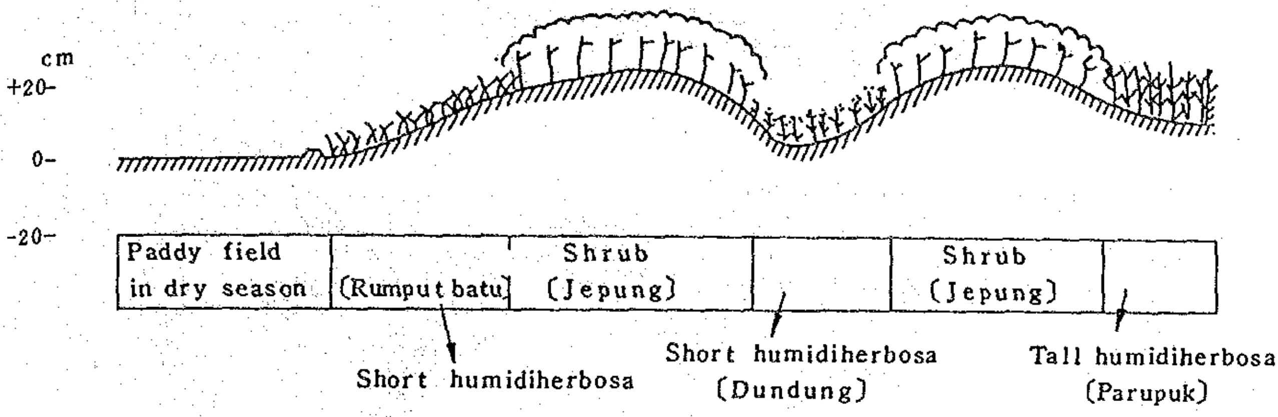


Fig. 9.12 (a) Cross-sectional View of Vegetation (1)

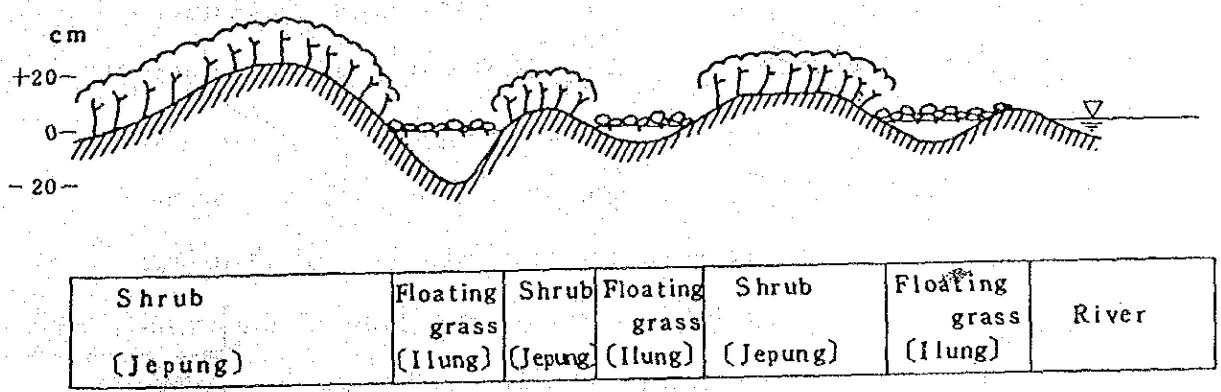


Fig. 9.12 (b) Cross-sectional View of Vegetation (2)

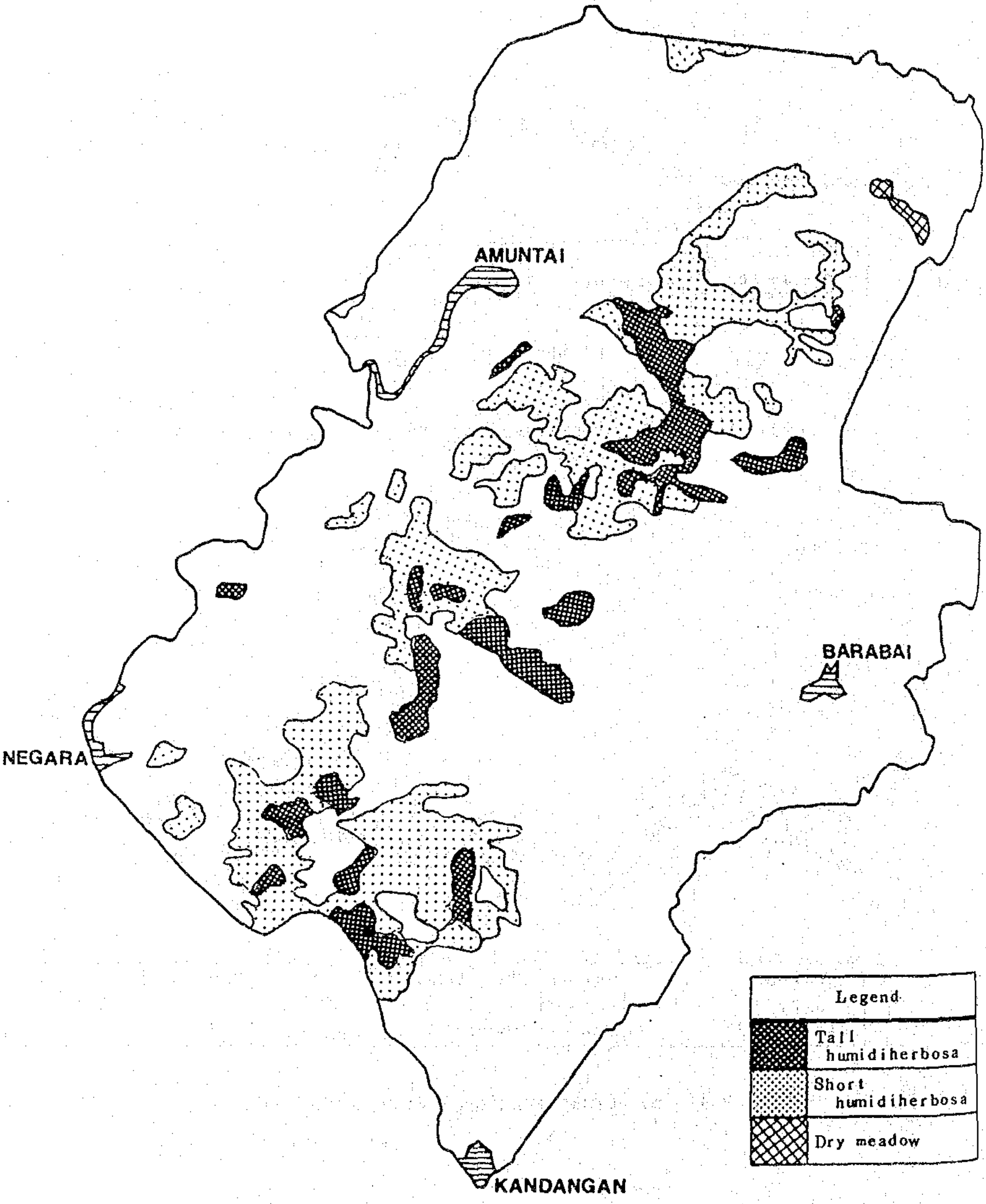


Fig. 9.13 Distribution of Grassland

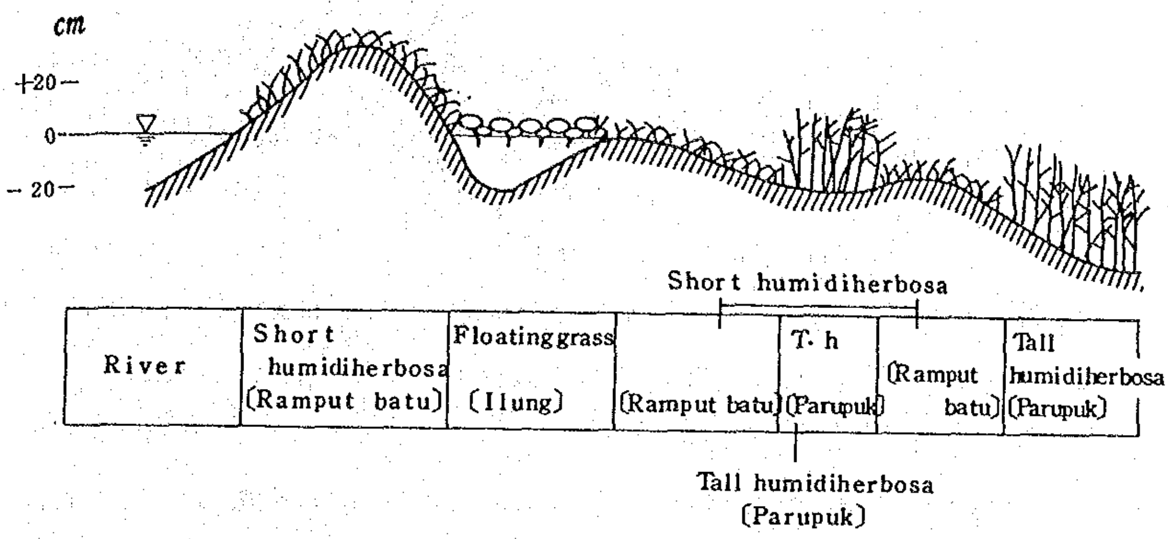


Fig. 9.14 The Cross-sectional View of Vegetation

Mostly, [Ramput batu] and [Dundung] prevail over the short humidiherbosa. Similarly to the tall humidiherbosa, their distribution area is considered frequently affected as covered with water. As compared with the tall humidiherbosa, the short humidiherbosa grows at a little higher altitude and at those areas which are significantly affected by flowing water and whose temperature varies remarkably between dry and rainy seasons or instable. The short humidiherbosa which has been artifically affected by firing or the like, however, does not show an express difference from the ground height of tall humidiherbosa. Besides, leaves of the short humidiherbosa may cover the water on the surface. Therefore, it cannot be always said that the short humidiherbosa is distributed at a relatively high land. (See Fig. 9.15.)

8) Tall Humidiherbosa

Tall humidiherbosa occupies an area percentage of approximately 3% and is distributed in some low humid areas of the deltas in addition to the swamp. (See Fig. 9-13.) In the swampy area, tall humidiherbosa constitutes a main landscape together with shrubs and short humidiherbosa. In this grass field dominate mainly 2 - 3 meter high reeds, <Phragmites crassipes> [Parupuk]. In the swampy area, tall humidiherbosa is located in a slightly lower area than that of short humidiherbosa. Most of these areas are submerged in rainy season. Nevertheless, tall humidiherbosa tends to grow at those portions which are scarcely affected by the flowing water. (See Fig. 9.14.) In dry season, water pools exist inside the tall humidiherbosa, which is located on a muddy ground.

9) Short Humidiherbosa

Short humidiherbosa occupies an area percentage of approximately 16%, widely spreading over the swamp. (See Fig. 9.13.) This grass field mainly comprises a species of true grasses, Gramineae s.p. <Echinochloa crus-galli Beav.> [Ramput batu], a species of galinales, Cyperaceae s.p. <Scleria purpurascens Steud.> [Dundung] and a species of ferns, Pteridophyta <Blechnum orientale L.> [Hiring]. In addition, a species of polygonums, Polygonaceae s.p. <Polygonum barbatum L.> [Cukat], a species of epilobiums, Onagraceae s.p. <Ludwigia linitolia Vahl.> [Pipisangan] and a kind of true grasses [Banta] also grow, having a grass height of approximately 50 - 100cm.

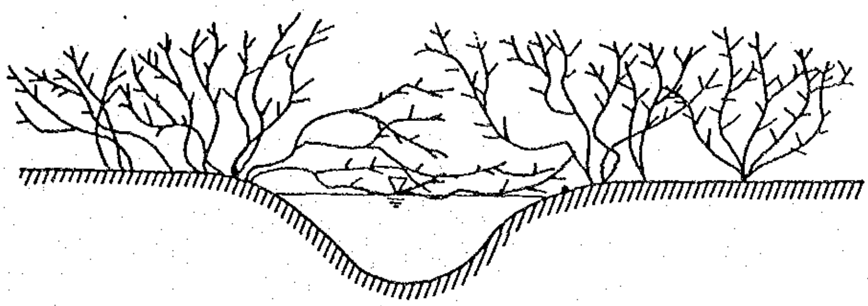


Fig. 9.15 The Cross-sectional View of Short Humidiherbosa

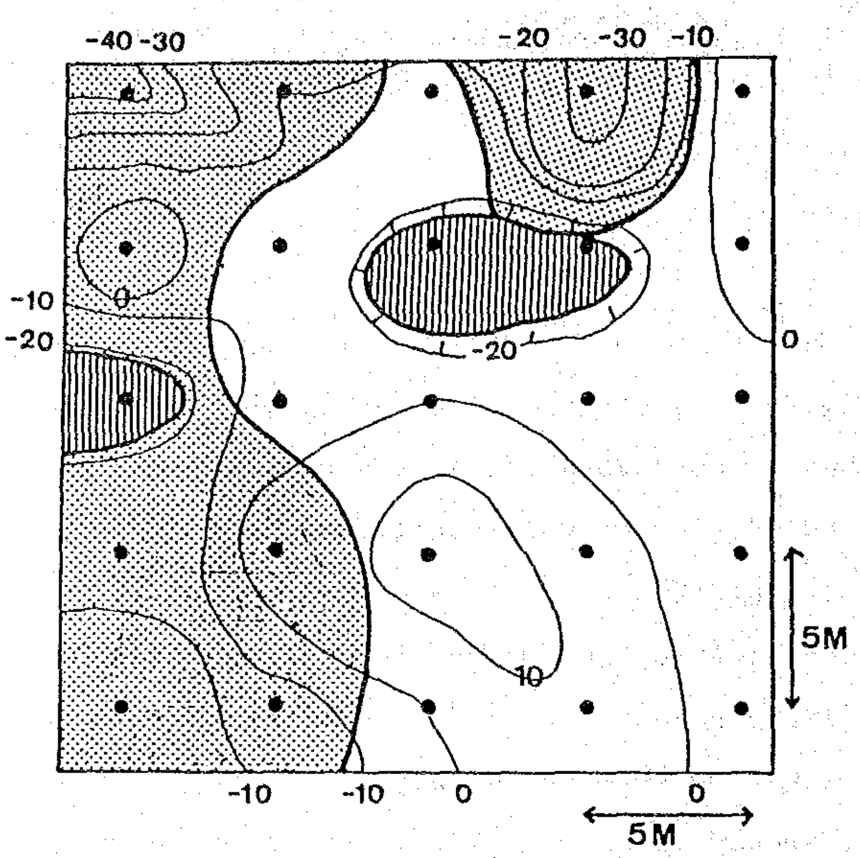
Fig. 9.16 shows the relative height of terrain and distribution of vegetation as measured in intervals of 5 meters over the zone where tall and short humidiherbosas are distributed.

According to the figure, the area where floating grass [Ilung kayuapu] is distributed has the lowest height of terrain. Next to this, the tall humidiherbosa [Parupuk] has the second lowest height and the short humiherbosa [Rumput batu] is the highest. The area where [Hiring] is distributed is located on the circumference of natural forests. [Banta] grows at slightly high portions in the swamp. These locations tend to be slightly dry in dry season.

10) Dry Meadow

Dry meadow occupies an area percentage of less than 1% and grow limitedly to slightly dry areas on natural levees and hills.

Dry meadow <Impenata cylindrica var. major C.E.>. [Alang-alang] is born as a result of lumbering and firing



Unite of contour lines : cm

Legend	
(vertical hatching)	Floating grass 〈Eichhornia crassipes〉
(dotted)	Tall humidiherbosa 〈Phragmites crassipes〉
(blank)	Short humidiherbosa 〈Echinochloa crus-galli Beauv.〉

Fig. 9.16 Relation between Relative Height of Terrain and Distribution of Vegetation

a forest. Therefore, its growing ground has an altitude equivalent to that of forests.

11) Floating Grass

The floating grass mainly comprises <Eichhornia crassipes>. [Ilung], including [Kayuapu], [Tanding] and [Jamai], among others. All of them are the plant which is afloat on the water surface. Though irrespective of water depths, [Ilung] could be seen in a flowing water area while [Kayuupu], [Tanding] and [Jamai] are observed in a stagnant water area.

In dry season, the floating grass is distributed in old river channels, water areas and swamps. In rainy season, it grows closely together anywhere in water covered areas.