

METHODOLOGY OF ENVIRONMENTAL RESEARCH FOR NEW
SETTLEMENTS IN THE EASTERN SULAWESI (INDONESIA)

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ABSTRACT

Methodology and evaluation of the suitability of land areas for new settlements in Eastern Sulawesi (Indonesia) are described and discussed from the agro-pedological point of view. The desired size of each area to be destined for human settlements is 1600 hectares.

The methodology developed, based on aerial photointerpretation and field checks, leads to the definition of land units resulting from the photointerpretation data and soil analyses.

The present research is part of the "Third National Five Year Plan (1979/80 - 1983/84)" of the "Transmigration Settlements Development" of the Indonesian Government.

RESUME

La méthodologie et l'évaluation de l'idonéité de terrains pour de nouvelles implantations dans le Sulawesi Est (Indonesie) sont décrites et analysées du point de vue agro-pédologique. L'aire requise pour chaque zone à destiner aux implantations humaines est de 1600 hectares.

La méthodologie développée, se basant sur l'interprétation photographique et sur des contrôles sur le terrain, amène à la définition d'unités de terrain résultant des données de l'interprétation photographique et des analyses du sol.

La présente recherche fait partie du "Third National Five Year Plan (1979/80 - 1983/84)" ("Troisième Plan Quinquennal National") du "Transmigration Settlements Development" ("Développement d'implantations de migration") du gouvernement Indonésien.

HAUPTINHALT

Die Methodologie und die Eignungsbewertung von Gebieten für neue Siedlungen im östlichen Sulawesi (Indonesien) werden vom agro-pedologischen Gesichtspunkt beschrieben und erörtert. Die Ausdehnung einer jeden für menschliche Siedlungen bestimmten Fläche sollte 1600 Hektar betragen.

Die erarbeitete Methodologie, die auf der Auswertung von Luftaufnahmen und auf Feldkontrollen beruht, führt zur Ausmachung von Gebietseinheiten, die aus den Daten der Photoauslegung und aus Bodenuntersuchungen hervorgehen.

Die vorliegende Untersuchung bildet einen Teil des "Dritten Nationalen Fünfjahresplans (1979/80 - 1983/84)" des "Transmigration Settlements Development" ("Entwicklung der Auswanderungssiedlungen") der indonesischen Regierung.

INTRODUCTION

The objective of this study was to determine a certain number of areas suitable for new human settlements.

This study is part of a multi-year program, the "Third National Five-Year Plan (1979/80-1983/84)" of the Indonesian Government designated as the "Transmigration Settlements Development". This program is directed towards permitting absorption of the increase in rural population over the next 20 years.

The areas proposed by the Indonesian Government have an overall surface of about 25.000 ha, within which at least 3 zones of 8.000 ha each must be found which can be destined as areas suitable for new human settlements (4 to 5 settlements/zone).

Each new settlement, composed of around 350 families is to consist of around 1600 ha, divided as follows:

- 3.25 ha per family, destined for agricultural use;
- 0,25 ha per family, destined for dwellings;
- 0,25 ha per family, destined for community services (roads)
- 300 ha per village, destined for use as pasture land and forest reserves.

The selection of these areas should be carried out on the basis of the following parameters:

- accessibility via land and via waterways (rivers and/or sea);
- morphology, according to 3 categories of slope, 0-8 %, 8-15 % and greater than 15 %;
- degree of flooding;
- use of the soil according to 9 categories;
- soils, with indications of the predominant type of soils and specification of possible limitations to their use caused by, for example, toxicity, depth of peat, rocky cover.

Two areas were studied for this report, both located in the central part of the Celebes or Sulawesi and more precisely in the zone of Kolonodale along the eastern coast between the villages of Tampira, Mahoni and Solonsa.

METHODOLOGY USED IN CARRYING OUT THE STUDY

Because of the absence of any basic cartographic data, the work essentially is based, in the preliminary phase, on the interpretation of aerial photographs, generally on an average scale of 1/20.000 and of very variable quality from strip to strip (ranging from poor to good).

In addition, the absence of a reference network, on the ground, of trigonometric points or more simply of elevation points, made it impossible to set-up a controlled mosaic to serve as the basic cartographic reference.

For these reasons, when developing the methodology for

this study, it was necessary to take into account the absence of such information as well as the poor accessibility of the more interior zones (i.e., those farthest from the coast) covered with dense primary forest which often was impenetrable.

This methodology can be divided into the following phases:

- setting-up an uncontrolled mosaic
- preliminary photointerpretation
- field checks
- final photointerpretation
- restitution on the mosaic
- setting-up elementary thematic maps
- preparation of the land units map

DETAILS OF THE METHODOLOGY USED

Uncontrolled mosaic (to be used as a basic cartographic document)

In preparing the uncontrolled mosaic on the basis of a quick reading of the photographs, errors due to variations in scale of the photographs and non negligible values of \hat{k} , were distributed in the margins of the areas involved and clearly indicated as areas to be thrown out in the choice of the 8,000 ha lots for the settlements. This procedure allowed a simplified map of the access ways to the interested areas to be drawn.

Preliminary photointerpretation

The objective of this procedure was to define the morphological characteristics of the area, including the determination of 3 categories of slope as well as the recognition and specification of the areas of the 9 soil categories.

Field checks

In addition to along the access routes, field checks were made along transverses located in the more interesting points from both the morphological and soil use points of view. In order to improve the definition of the categories of slope, precision levelling was carried out along the transverses, taking care that the reference points were always surely and easily identifiable on the photographs.

Pedological observations were made and samples of various types of soil were collected.

Final photointerpretation

On the basis of the field data and thus on the calibration of the photographs with the definition of the "key interpretative features" chosen on the basis of their location and quality of the images, it was possible to control the preliminary photointerpretation studies and to establish further details.

Restitution on the mosaic

In order to obtain greater precision, all the photointer-

pretation data, written down on the transparent and undeformable templates (Kodatrace) were restituted on the photomosaic with the integration of the field data.

Setting-up the elementary thematic maps

The data on the photomosaic, which serves as data-bank, were then recopied according to theme on the basic map indicating access routes, etc. The following two thematic maps, referred to as "elementary maps" were prepared:

- 1) Simplified geomorphological map, including waterways, the principal and secondary watersheds and the slopes.
- 2) Land-use map, including the pedological data.

The combination of these two "elementary maps" with the addition of the results from the laboratory analyses on the soil samples collected, provided the necessary information for the preparation of the final map of the land units which characterize the two areas studied and permit the selection of the 8,000 ha zones most suitable for establishing settlements.

GEOMORPHOLOGICAL, HYDROLOGICAL, VEGETATIONAL AND PEDOLOGICAL CHARACTERISTICS OF THE LAND UNITS

Brief descriptions of the agro-pedological characteristics for each of the land units found in the areas studied are given in this section. These characteristics also can be found in a schematic form in the legends of the maps included with this report, whereas, the pedological and physical-chemical data for the soils are reported in Table 1.

Land units "e" - Marine system areas

These areas characterized by permanently flooded, coastal, mangrove swamps that boarder a large part of the coastline. For the most part they are submerged areas where the water can reach depths of 1 to 2 meters.

The present land use is exclusively as a swamp forest, represented mainly by the mangrove.

Land units "a₁" - Alluvial marine system areas

The "a₁" land units correspond to flat areas that boarder the coastal zone and whose altitudes are approximately that of the average level of the sea. They extend in a discontinuous strip which has wide breaks (near Mohaino and Bahonsuai) and alignments of paleodunes or low coastlines which determine the distribution of small coastal lagoons.

Such swamps are widespread to the NW, while fixed dunes of modest heights (max 2 m) are predominant to the SE. These areas are subject locally to phenomena of tides and at the same time receive abundant deposits from inland, depending on seasonal factors.

Land unit	Soil (*)	Horiz	Depth cm	Colour (Munsell)	pH H ₂ O	Particle size anal.		Organic matter			Cation exchange me %					Available elem.ppm					Total element ppm				
						Clay %	Silt %	Sand %	% C	% N	C/N	H	Ca	Mg	K	Na	P	Cu	Mn	Ni	Cr	Cu	Mn	Ni	Cr
a ₁	THIONIC FLUVISOL	Ap	0-10	10 YR3/1	3,9	25	43	32	3,39	0,25	13,6	22,8	0,3	0,2	0,2	0,1	8	2	9	4	1	20	169	350	5089
		Btg ₁	10-25	7,5YR4/2	4,0	36	38	26	0,47	0,14	3,3	18,0	tr	0,2	0,2	0,1	5	1	3	3	1	35	189	1900	4200
		Btg ₂	25-65	7,5YR5/2	4,4	48	31	21	0,12	0,08	1,5	8,1	2,1	7,8	0,7	10,1	4	1	1	10	1	29	700	1200	1108
		Cg	65-120	5 Y 4/1	4,6	67	15	18	0,41	0,09	4,5	20,3	tr	tr	tr	0,1	4	tr	1	19	2	70	780	1600	1600
a ₂	EUTRIC GLEYSOL	Ap	0-25	5 Y 4/1	5,4	12	22	66	0,99	0,11	9,0	8,3	3,6	tr	0,1	0,1	9	2	15	7	tr	31	489	167	83
		Bg	25-45	2,5Y 6/0	5,8	16	26	48	0,35	0,09	3,9	10,8	3,3	1,3	tr	0,1	5	2	14	44	8	45	700	9345	3447
		Cg	45-80	2,5Y 6/2	5,0	31	27	42	15,15	0,68	22,3	33,6	2,6	16,6	0,1	0,2	7	1	10	28	4	47	786	2450	2611
b ₁	HUMIC ACRISOL	A	0-25	10 YR2/1	6,2	36	27	27	3,27	0,29	11,3	13,1	5,9	24,5	0,2	0,5	21	4	28	23	tr	59	2209	1200	1125
		AC	25-50	7,5YR4/4	6,6	36	28	36	1,46	0,11	13,2	14,0	5,8	18,3	0,1	0,3	12	3	20	18	tr	81	1600	1600	1200
b ₂	EUTRIC CAMBISOL	Ap	0-30	10 YR4/3	5,4	40	25	35	1,64	0,14	11,4	16,3	3,2	183,5	0,3	0,2	4	2	67	28	7	61	4783	1389	4219
		B	30-60	10 YR3/4	7,3	57	14	29	0,53	0,07	7,1	26,3	2,4	269,6	0,4	0,5	3	1	29	29	8	90	1303	2369	2029
c ₁	FERRIC ACRISOL	Ap	0-30	10 YR3/3	4,8	32	23	45	0,70	0,06	11,7	13,8	0,9	38,0	0,1	0,3	3	2	151	18	5	97	4928	1028	3428
		Bt	30-60	5 YR5/6	5,0	38	27	35	0,41	0,06	6,7	13,8	1,3	49,8	0,1	0,1	2	1	146	19	6	106	9275	1250	3692
		BCg	60-100	10 YR6/4	4,9	40	21	39	0,18	0,01	28,6	13,7	2,1	85,3	0,2	0,1	2	1	128	16	4	108	1170	1454	1660
c ₂	FERRIC ACRISOL	Ap	0-30	10 YR4/2	4,7	36	17	47	0,88	0,12	7,5	21,2	1,9	119,0	0,5	0,1	4	1	69	36	1	63	3204	2000	4615
		Bt	30-60	7,5YR4/4	5,3	54	17	29	0,70	0,07	10,0	21,3	3,9	180,1	0,6	0,1	2	1	38	25	6	79	2093	2403	5961
d	ORTHIC FERRALSOL	A	0-10	7,5YR2/2	4,9	24	44	32	1,99	0,19	10,5	21,9	0,1	0,5	tr	0,1	7	2	85	28	2	39	3076	6116	1188
		AB	10-50	7,5YR4/2	4,8	31	47	22	1,23	0,17	7,2	18,8	tr	0,4	tr	0,1	6	1	64	11	4	68	1076	750	262
		Bs	50-100	5 YR4/8	5,0	43	41	16	0,29	0,09	3,2	16,0	6,6	3,9	0,2	2,8	2	1	16	36	7	72	2088	3900	1500

(*) FaO-Unesco Classification

Table 1 - PEDOLOGICAL AND PHYSICAL-CHEMICAL DATA FOR THE SOILS OF THE LAND UNITS

The vegetation consists predominantly of swamp forest at various water table levels, depending on the distance from the coastline.

The soils, whose substrates are characterized by recent fluvial and marine deposits, with mainly a clay-silt texture, have been affected by intense gleyfication processes, even in the less deep horizons; the presence of marine water and sulfur containing minerals gives these soils a high sulfur content (Association ; Thionic fluvisols - Gleyc solonchaks - Humic gleysols).

Land units "a₂" - Alluvial system areas and river beds

To the left of Sungai Laa, between Sungai Laa and Sungai Tambalako, there is a wide flat area whose slope is less than 3%. This zone, which includes land adjacent to the rivers as well as between meanders, represents the connecting strip between the coastal area and the main landforms with undulating morphology. Because of their location, these areas are often subject to flooding but not periodically as is the case for the "a₁" land units. However, because of the water table level in the vicinity of the rivers, the surface soils of these land units also are hydromorphous with gleyified horizons. The substrate, characterized by sandy-silty alluvial sediments, has good drainage which, however is slowed down or blocked at a certain depth because of the presence of the water table level, often saline, which, therefore can lead to the development of concentrations of salts and sulfur in the lower horizons (Association: Thionic fluvisols - Eutric fluvisols - Eutric gleysols).

Land units "b₁" - Plain system - Marine terrace areas

The "b₁" land units correspond to an area whose slope is between 0 and 3 % which is located along a strip of discontinuous width between the hilly zone and the coastal one; this area is predominantly dry, however, two or three times a year it can be subject to local flooding, relatively modest in extent as determined by seasonal and morphological factors. The area is crossed transversely by some main rivers (Sungai Ungkaia, Sungai Karoupa, etc.) and by a minor, predominantly SW-NE river network. Surface drainage takes place regularly and it is only in the vicinity of the coast at the borders with the "a₁" land units that the main rivers tend to be dispersed in a series of small streams.

The present land use in this area is that of pattern cultivation of rice ("Ladang" or "Sawah"); another large part of the area is covered by grass (uncultivated soil) and sometimes by secondary growth. Near the southwest edge of the area there is a continuous strip of dry forest in the vicinity of the foot hills zone.

The pedological substrate is characterized by colluvium de

rived from erosion of the hinterland whose lithology is predominantly basic and ultrabasic; such heterogeneity has given rise to a soil with a more or less equilibrated texture (clay-silt to silt) and thus with regular drainage but which is not very thick (Association: Distric cambisols - Eutric cambisols - Humic acrisols).

Land units "b₂" - Sub-units within "b₁" unit

The "b₂" land units indicate areas of limited extension adjacent to or included within land units "b₁" whose slope is near to 0. They are characterized by seasonal flooding since they are depressions or areas of less slope than the adjacent area which, therefore, allows the formation of partial, flooded fresh water, swamp land.

The present land use for these areas is as swamp grass land or swamp forest and sometimes, where possible, for wet rice cultivation and coconut plantations.

Land units "c₁" - Undulating land with hilly areas

The "c₁" land units represent a discontinuous strip of land connecting the hilly area (Piedmont plane) and the mountainous area (land units "d"). For the most part, the slopes in the "c₁" land units areas are less than 15 %; the morphology is slightly undulating with a network of river valleys.

Present land use is as dry forest; sometimes there also are small swampy areas where typical swamp forest vegetation is found.

The characteristics of the soils are analogous to those for the "c₂" land units, with the exception of those soils found within the small swampy areas where the local formation of soils of a hydromorphous nature has occurred.

Land units "c₂" - Piedmont plain system areas

These areas consist of a series of hills, often relatively flat valleys. Their slopes are extremely variable; however, slopes from 8 to 15 % are the ones most frequently observed. There are some escarpments which, however are of a limited extension. The water network is regular and often has an angular pattern determined by the structure of the area.

Present land use is as dry forest; swampy areas are practically non-existent.

The soils, moderately deep, are developed on locally conglomerated alluvial deposits which laterally shift to effusive material; the texture varies from silty on the surface to clayey at deeper levels where illuvial clay horizons appear along with sesquioxide concretions (Association: Humic acrisols - Ferric acrisols).

Land units "d" - Steep hilly areas

The "d" land units are in reference to the more internal

part of the territory under study. These areas consist of a hilly-mountainous system with slopes predominantly greater than 15 %. The altitude varies from a minimum of 50 m to a maximum of over 400 m. This mountain system has passes corresponding to the Sungai Bahumbelu and the Sungai Ungkaia. The surface hydrography usually is developed in dendritic patterns which flow into each other in the pedimont zone. The morphology of this area is very irregular and sometimes there are crests and abrupt escarpments. At the lower altitudes, the area consists of a hilly strip with less developed slopes.

The vegetation is predominantly dry forest even though there also are some small swampy wet forest areas.

Because of the eruptive, basic and ultrabasic substratum, the soils which develop are moderate in depth; the clay content increases progressively from top to bottom of the profile because of intense leaching phenomena as well as alteration of the base-rock.

In correspondence with the clay horizons, in addition to abundant ferro-manganese concretions, there also occur frequent slickensides and variations in color indicative of slow internal drainage. Although these soils are characterized by intense acidification along the entire profile, they also have a high organic matter content in the first 30 to 40 cm (Association: Humic acrisols - Orthic ferralsols - Humic ferralsols).

SUITABILITY OF THE LAND UNITS FOR HUMAN HABITATION AND AGRICULTURAL USE

The information collected regarding the agro-pedological characteristics of the areas studied (briefly reported in this paper) allowed the degree of suitability for human habitation and agricultural utilization to be established for each of the various land units.

With regard to the suitability for human habitation, the areas designated with land units "e", "a₁" and "a₂" can be definitely excluded because of the periodic flooding to which they are subjected as well as the intense hydromorphology of the soils present; land units "d" also can be excluded for human habitation because of the particularly difficult geomorphology.

Areas which can be considered somewhat suitable for human habitation are those designated as land units "c₁" and "c₂", in the areas which are not swampy and the land is relatively flat.

The areas most favorable for establishing human settlements are those designated as land units "b₁" and "b₂"; these are the areas which are more or less flat, with limited risk of flooding and/or the formation of swamps.

With regard to suitability for agricultural use, there are various problems, in general for all the areas studied and in particular for land units "b₁", "b₂", "c₁" and "c₂".

The physical-chemical data for the soils, correlated with the pedological information (Table 1), for the most part indicate anomalies or deficiencies to such an extent as to have negative effects on the introduction of new crops as well as on the productivity of those crops presently existing in the areas.

The pH is so low that it has a negative influence on the other physical-chemical parameters of the soils and specifically on the organic matter which would be easily degraded as a result of agricultural use, with the consequent loss of many nutritive elements. The soils, in general are very low in available phosphorous and exchangeable potassium. The exchangeable cation ratios (alkalis and alkaline earths) are not optimum and the total copper contents are extremely low and always less than 100 ppm.

The most unsatisfactory factor, however is the presence in these soils of very high amounts of some elements which, when present above certain critical levels, become toxic for all types of crops. Among these, the values of total manganese, nickel and chromium are almost always greater than 1000 ppm.

On the basis of the above considerations, it seems evident that even in those areas where the conditions for developing suitable agriculture capable of supporting the resident population are lacking.

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