SOILS AND SOIL CONDITIONS
UPPER KALI KONTO WATERSHED

EAST JAVA - INDONESIA

REPORT PREPARED FOR PROYEK KALI KONTO ATA 206

1984

NUFFIC - UNIBRAW
SOIL SCIENCE PROJECT

SOIL SCIENCE DEPARTMENT
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UNIVERSITAS BRAWIJAYA
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MALANG

Republic of Indonesia
Ministry of Forestry
Directorate General of
Reforestration and Land
Rehabilitation (RRL)

Kingdom of the Netherlands
Ministry of Foreign Affairs
Directorate General of
International Cooperation
(DGIS)

SOILS AND SOIL CONDITIONS

KALI KONTO UPPER WATERSHED, EAST JAVA

Final Document

August 1984

UNIVERSITAS BRAWIJAYA, MALANG
AGRICULTURAL UNIVERSITY, WAGENINGEN
PROJECT NUFFIC-UNIBRAW-LHW-SOIL SCIENCE

PROYEK KALI KONTO, MALANG
ATA - 206

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

Tables

LIST OF SEPARATE MAPS

FOREWORD

In response to a request of the Kali Konto Project, the Soil Science Department of the Faculty of Agriculture of Universitas Brawijaya in Malang carried out a detailed soil survey and physical land evaluation study of the Upper Kali Konto Watershed.

The Upper Kali Konto Watershed is the project area of the Kali Konto Project. The project was initiated in 1979 to carry out a case study in which the Governments of Indonesia and the Netherlands cooperate to develop a planning procedure for the establishment of a management model for forest land in densily populated watersheds on Java.

The soil survey of the project area was undertaken to collect basic data on the soils and their spatial distribution, required for the proper planning and use of the land resources in the area.

The study was also part of the training programme of the Nuffic-Unibraw Soil Science Project, a project of cooperation between the Agricultural University Wageningen, the Netherlands and Universitas Brawijaya in Malang, Indonesia.

The Kali Konto area is considered an ideal training ground for staff and students in soil survey techniques, aerial photointerpretation, soil classification and land evaluation procedures.

The study, commissioned in November 1982, was carried out from December 1982 till March 1984. The results of the study are treated in this report. It describes the soil conditions of the area and the morphological, physical and chemical properties of the individual soils as delineated on the soil map. It equally describes the physical suitability of the lands for various land use alternatives, both actual and potential.

The authors hope that this volume will make a worthwhile contribution to the planning and development of the area. They also hope the report will be used as a case-study for soil science students of Universitas Brawijaya and that the area will become a permanent field laboratory. Research on soils, their management and behaviour under various management systems is only possible when basic data on their properties and characteristics are well known and documented.

Malang, May 1984

Soil Science Department
Faculty of Agriculture,
Universitas Brawijaya

Nuffic/Unibraw/Agricultural
University Wageningen
Soil Science Project

ORGANIZATION OF THE STUDIES

The survey was carried out by staff of the Soil Science Department of Universitas Brawijaya, Malang, from December 1982 till March 1984. The following staffmembers of the Department participated in the survey :

- ir. Mochtar Lutfi Rayes (project coordinator)
- ir. Abdul Mukri Prabowo
- ir. Widianto MSc
- ir. Sudarto
- ir. Sugeng Priyono

Ir.Budi Santoso, Dipl.Agr., Head of Department, programmed the work and fitted the study in the overall workprogramme of the Soil Science Department.

Many Unibraw students participated in the field survey as part of their first degree training in soil science. A number of students also carried out research on specific subjects such as soil catenary studies, soil-water relationship studies, soil fertility studies and soil erosion studies. The results of their studies and investigations are incorporated in this report.

In conjunction with the survey, soil erosion studies on run-off plots were carried out on representative soil types and slope gradients under various cropping systems and management practices. The studies were financially supported by the DAS Brantas Project in Malang en were conducted by Dr.Wani Hadi Utomo and Ir.Widianto MSc.

Collected soil samples were analyzed in the laboratories of the Soil Science Department of Unibraw under the supervision of Dr. Slamet Setyono and Ir. Yulia Widianingsih (soil chemical analysis) and Dr.Wani Hadi Utomo (soil physical analysis). The following staffmembers of the Department were in charge of the analysis

- ir. Endang Listyarini (Mrs)
- ir. Kurniatun Hairiah (Ms)
- ir. Retno Suntari (Mrs)
- Ms. Sunarsih

Students participated in the laboratory analysis as well.

Mr. G.W.van Barneveld, Soil Resources Specialist of the Nuffic-Unibraw-Agricultural University Wageningen Soil Science Project acted as consultant and technical advisor of the studies. Mr. D.Legger of the same project guided the laboratory staff with the interpretation of the analytical results.

The final report has been prepared mainly by Messrs. Lutfi Rayes, Mukri Prabowo and Widianto. Mr. G.W.van Barneveld assisted in the preparation and was in charge of the final editing. Mr. Sudarto did all the map compilation and drafting.

ACKNOWLEDGEMENTS

The survey and studies would have been impossible without the help of many individuals and organizations.
The survey team is particularly grateful for the support of

- the Rector of Universitas Brawijaya and the Dean of the Faculty of Agriculture who permitted the team a balanced programme of work within the margins of available time and resources
- the Proyek Kali Konto for their confidence in the Soil Science Department and their constructive and stimulating criticism
- the Netherlands State Forest Service (SBB), the Research Institute for Nature Management (RIN) and the International Institute for Aerial Survey (ITC) for their help to print the final maps
- Proyek DAS Brantas for providing meteorological data and financial support for the erosion studies

- the village heads and farmers in the area of the survey for their hospitality, assistance and understanding
- our colleagues at Unibraw for taking over our tasks of teaching and lecturing, while we were away from the campus.

HOW TO USE THIS REPORT

An important part of any soil survey report is the basic soil map. Soil maps provide probably the most satisfactory means of conveying soil resource data to the user.

The final soil map of the Kali Konto area has been printed on a 1:25.000 grey-tone orthophotomosaic. The use of an orthophoto-mosaic as base-map has the advantage that each individual farm and tract of land can easily be located on the map. The final soil map is intended as a tool for (sub)watershed planning and land use planning at the village level.
As the map is likely to be used by many people, it has been decided to prepare easy reproducible black and white diazoprint copies as well. The original of these maps are retained in the Soil Science Department of Universitas Brawijaya in Malang and paper or transparent copies can readily be made available.

Every area delineated on the soil map is identified by a particular symbol and the map legend, printed separately, explains the meaning of each symbol. All areas with the same symbol together form a soil mapping unit. All symbols are in the form of a fraction. The numerator of each symbol indicates the landform type and the denominator refers to the soil unit or units found in that particular mapping unit. An example is unit $\frac{Pm}{Te}$. In this symbol Pm stands for "intervolcanic middle plain", a landform unit. T stands for "Tawangsari series", as can be seen in the second column of the legend. The suffix "e" indicates that the soils are moderately eroded (soil phase).

The soil patterns in the area vary considerably. On a particular landform type different soil units may be found, while a particular soil unit may occur on more than one landform type. There are thus many "combinations" of landforms and soil types and a total of 56 such combinations ("mapping units") have been recognized.

In the legend, the mapping symbols are arranged approximately from the lowest areas (alluvial valleys) to the highest mountains. The legend indicates also the slope type, slope class, as well as the type and degree of present erosion (column 3 of the legend). In the last column the soils are classified according to the US Soil Taxonomy.

A soil classification correlation table is found at the back of the legend. The table gives the equivalents in the Indonesian (LPT, 1981) and the FAO/UNESCO soil classification systems.

For a description of the properties and characteristics of the soils of individual mapping units, reference is made to Section IV of this report. In this section the soils and soil conditions are described in detail, the soil units being listed alphabetically. The descriptions are easy to understand, also for the non-specialist. More detailed morphological and analytical laboratory data, to be used by soil specialists, are found in the annex.

For the user requiring less detailed information reference is made to the generalized soil-, landform and soil erosion maps prepared at a scale 1:50.000. The generalized maps are coloured paper prints. Coloured maps have the advantage of showing better the spatial relationships between the various mapping units and the conditions of the watershed as a whole. The generalized maps are thus prepared particularly for the regional watershed and landuse planner.

SECTION I. INTRODUCTION

I.1. GENERAL BACKGROUND

In 1979, the Governments of Indonesia and the Netherlands initiated a cooperative project to develop a planning procedure for the establishment of a management model for forest land in densily populated watersheds in Java.

The watershed of the Upper Kali Konto has been selected for the project activities. The area of approximately 233 km^2 is situated in the Malang Regency of East Java, some 25 km Northwest of Malang and 95 km South of Surabaya. The watershed consists of a series of upland plateaus surrounded by steep slopes of several volcanic complexes, partly active (Kelud), partly dormant or extinct (Kawi-Butak and the Anjasmoro). The crests and steep ridges of the mountain complexes determine the boundaries of the watershed. The area is situated in several agro-ecological zones and the generally young, fertile and deep soils derived from volcanic materials, permit the cultivation of a relatively broad range of crops. Large areas of the steep mountain slopes are covered with forests, which makes the area a privileged region compared to many other parts of Java.

Almost two thirds of the watershed area consists of state forest land, which is still seen by the local population as de-facto common land, from which everybody is entitled by right to collect whatever wood or other products he may require.
The increasing imbalance between population growth on one hand

and the lack of land resources for the absorption of labour in the agricultural sector, together with a stagnant development of other economic sectors on the other hand, appears to lead rapidly to a situation of marginalisation of income for an ever growing part of the population. As a result, it could be said that the forest area increasingly act as a reservoir providing illegal subsistence for increasing numbers of landless and marginal farmers.

Perum Perhutani, the State Forest Corporation, is responsible for the management of the forest areas. The tasks of the Corporation include the maintenance of the forests and the development of its protective and productive functions. Within the limits and possibilities set by these main functions, the Corporation permits the local population, carefully and to a limited extent, to derive produce and income from forest land. Perum Perhutani's general policy is thus (i) to create, maintain and protect stable ecological forest systems, (ii) to create multipurpose forest systems fitting into the national forest policy and (ii) support and improve the living conditions of the local communities.

Considering the above, the objectives of the cooperative Proyek Kali Konto are to draw up proper watershed management and master plans in such a way that a proper balance can be achieved and maintained between the several functions of the forest and the needs of the population.

The nature of the problem of the rapid deterioration of the forest resources and their main protective, productive and hydrologic functions, lies in overpopulation and a rapid deteriorating ratio of people to resources. The Proyek Kali Konto has taken the praiseworthy initiative to analyse this pressing problem and to find ways to improve the situation.
However, the complex problems necessarily require actions not limited to the forest areas and sector alone. Instead, the entire

watershed, including both the forest and agricultural lands, need to be considered as one single integrated unit.

The preparation of proper watershed management plans require a number of preliminary studies and surveys of the physical, human and economic resources of the watershed. Basic information on the soils and soil conditions, as well as the assesment of their suitability for alternative land use systems are an important part of these preliminary studies. The purpose of the detailed soil survey reported in this volume, is to provide Proyek Kali Konto with this basic information.

I.2. THE UPPER KALI KONTO WATERSHED

The upper Kali Konto watershed covers an area of approximately 23.325 ha and is situated partly in the Kecamatan Pudjon (12.505 ha) and partly in the Kecamatan Ngantang (10.820 ha), Malang Regency, East Java.

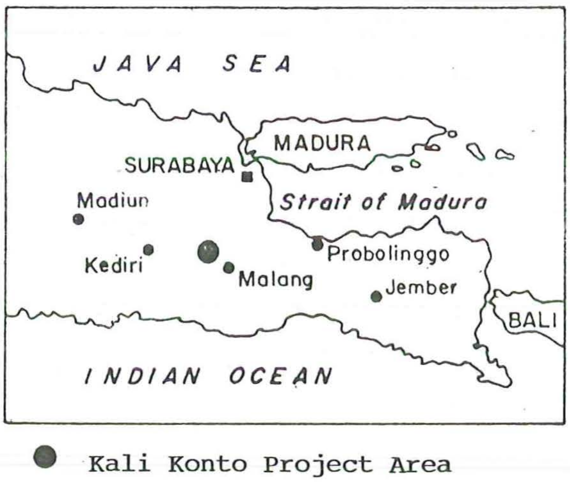

Fig.I.1. Location sketch Kali Konto area

The eastern (upper) part, situated in Kecamatan Pudjon [1], consists of a gently sloping and sloping intervolcanic plain, bordered by steep and very steep mountain slopes of the twin volcanoes Gunung Kawi and Gunung Butak in the South and the Anjasmoro range in the North. This part of the area is situated between approximately 850 and 2650 meter above sealevel, with agricultural areas between 950 and 1300 meter. The area is a major vegetable growing area, supplying the markets of Surabaya and Malang. Dairy farming is equally important.

The western (lower) part of the watershed (the "Ngantang area"), is situated between 620 and approximately 1400 meter above sealevel. The area consists of three gently sloping and sloping intervolcanic plains situated between 620 and 800 meter: The plain of Kali Pinjal, between the Gunung Kelud and Gunung Kawi, the plain of Kali Kwayangan between the Anjasmoro and Luksongo hills and the plain of the Kali Konto, coming from the East. The plains constitute an important agricultural area with wetland rice based cropping systems on sawahs and upland crops and mixed coffee gardens and homestead on land not being irrigated.

Where the three plains meet, there is the Selorejo Dam and Lake. The dam has been constructed in the course of the second half of the nineteen sixties and is part of a much larger complex of works to control and regulate the Brantas river system. The main functions of the Selorejo dam are (i) flood control of the area below the dam, (ii) the provision of irrigation water during the dry season for 5700 ha rice land in the areas of Pare and Jombang and (iii) the generation of electricity (a turbine output of max 4.800 kW). (comm. DAS Brantas)
The Selorejo lake covers an area of approximately 280 ha and the waterlevel varies from 598 to 622 meter a.s.l. with an average

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1) the area is often referred to as the "Pudjon area".

high water level of 620 meters. A 600.000 m^3 capacity silt trap has been constructed upstream in the Kali Konto (Sabo Dam Tokol).

Of the 23.325 ha of the watershed, 15.625 ha is found within the forest boundary (the official forest area), although only part of the lands are actually covered by forests. The total village lands cover approximately 7.420 ha, of which 5.950 ha is farmland, partly sawah, partly tegallans and homesteads. Data from Dinas Pertanian (1980) and Perum Perhutani (1980-1983) on land use are as follows:

Table I.1. Landuse in the Kali Konto Watershed

natural forest	6.725 ha	sawah area	2.160 ha
plantation forest	1.090 ha	dry farm land	3.785 ha
scrub area	7.810 ha	desa's, homeyards	1.475 ha
total forest area	15.625 ha	total agricultural area	7.420 ha
Lake Selorejo 280 ha.		Total project area: 23.325 ha.	

Source : Dinas Pertanian (1980), Perum Perhutani (1979) and PKK (1982).

Fig.I.2. is a generalized landuse sketchmap, scale 1:80.000,based on aerial photointerpretation (aerial survey 1979). It provides an overall picture of the general natural vegetation and landuse units of the watershed. The map has been prepared by PKK.

I.3. THE FORESTS

The forests lands, or the area within the official forest boundary, covers approximately 15.625 ha (PKK data).

Roughly 7000 ha is covered by natural montane forests. These are essentially protection forests with important ecological functions

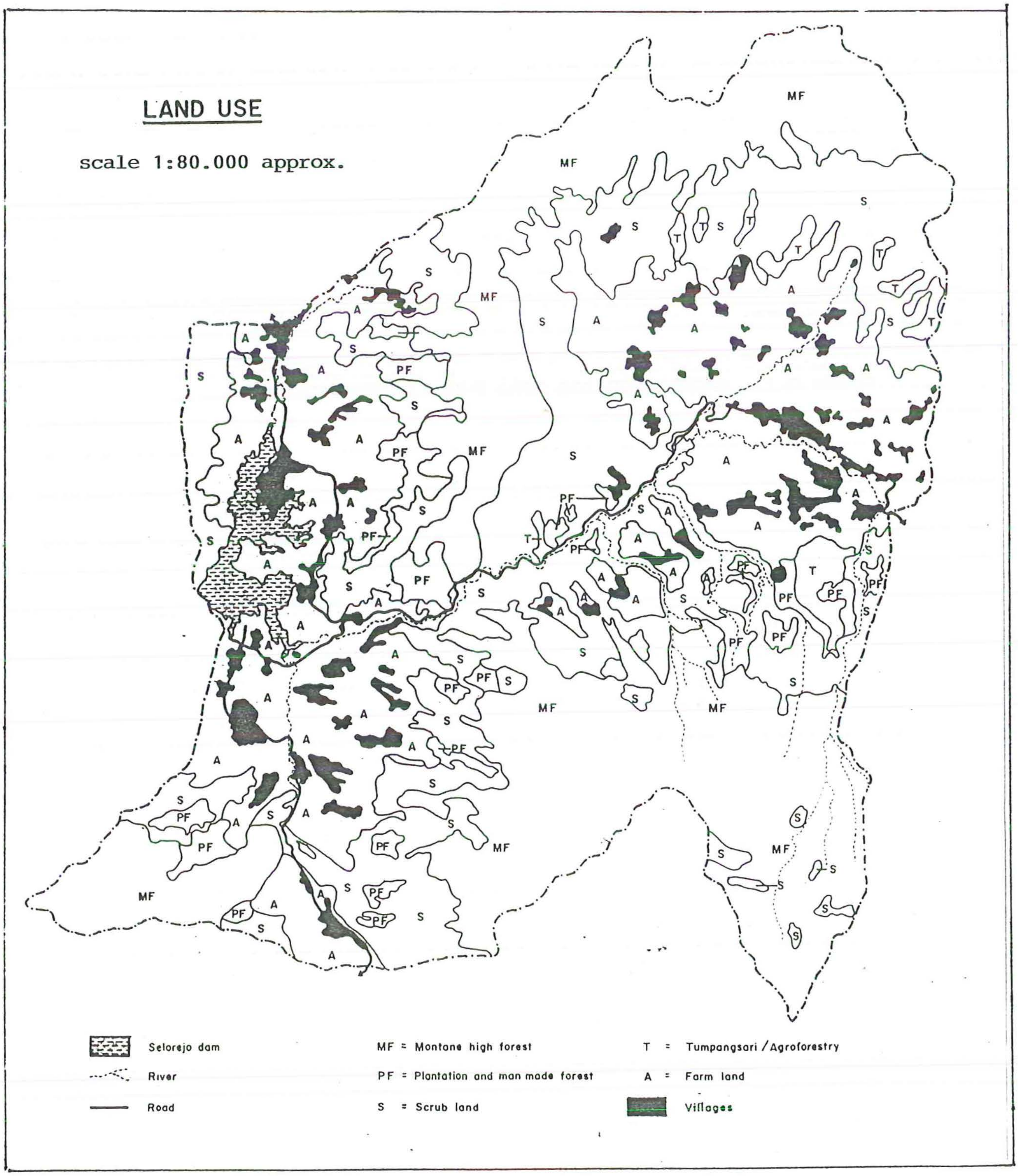

Fig.I.2. Landuse sketchmap Kali Konto project area such as soil and water conservation and serving scientific purposes. Most of the natural forests are found above 1400 meter in the submontane and montane ecological zone.

The most common type of natural forest is the mixed montane high forest with Lithocarpus spp, Engelhardia spicata, several Myrtaceae and treeferns as characteristic species, representing, maybe, the natural climax vegetation of the higher elevations. Several subtypes are recognized, being the result of local differences in climate, landform and natural erosion. There is a difference in species composition between the forests on the wet rain-facing slopes of the Anjasmoro Range and those on the drier nothern rain-shadow slopes of the Kawi-Butak complex. Intermittent volcanic activity of the Kelud greatly influenced the composition and state of the forest on the Kelud slopes.

A second major type is the Cemara forest, consisting of often fairly pure stands of Casuarina junghuhniana. The soil survey team found this forest type to exist particularly on the steep upper slopes of the Gunung Kawi and on the saddle between the Gunung Kawi and Butak. Cemara is fire resistent and the forest is the result of regular burning of the vegetation. The team found no relation between soil conditions and the presence of Cemara. As most of this forest type is found on the drier eastern slopes, it is possible that the humid conditions, which prevail throughout the year on the rainfacing slopes, prevent the spread of the forest fires and the cemara forest vegetation.

A significant factor influencing the natural forests is the human practice of cutting timber and fuelwood and the collection of fodder (young tree leaves). Degradation of the natural forests is particularly severe in the most accessible parts of the forests on the middle and lower slopes of the mountain complexes. Degradation and exploitation gradually change the vegetation from a closed canopy forest vegetation to a pure scrub "kirinyu" vegetation of dense thickets of Eupatorium inulifolium and Lantana camara. Both species originate from South America and were introduced in the Bogor Botanical Gardens during the last century from where they spread rapidly and uncontrolled over all of Java. Over 7800 ha, or one-third of the entire watershed, is presently covered by this unproductive scrub vegetation, including areas with remnants of the original natural forest. Foresters generally consider areas with a forest canopy cover of 20% or less as scrub area. (RIN. pers. comm.)

However, not all kirinyu areas are the result of indiscriminative logging and degradation. Between 1860 and 1880 vast areas of natural vegetation on the lower and even middle slopes of the mountain complexes were transformed into coffee plantations. Around the turn of the century a devastating fungus disease (Hemileia vastratix) killed most of the coffee and caused that most plantations were abandoned. Efforts to restore a protective or productive forest vegetation on these lands apparently failed.

Approximately 1100 ha of the forest lands are covered by plantation forests. It is likely that most of the plantation forests are situated on the old abandoned coffee gardens, on lands that are not too steep and with a good access. Important species are pinus (Pinus merkusii), eucalyptus (Eucalyptus spp), damar (Agatha loranthifolia), calliandra (Caliandra spp) and other minor species. Most stands are relatively young and vary considerably in quality and appearance (degradation, kirinyu infestation, etc.).

More and detailed data on the forest resources of the area will be presented in other reports.

1.4. POPULATION AND AGRICULTURE

Early history

Judging by ancient records of irrigation control and dam-building, as well as the archeological remains of some of the constructions still to be seen, the Ngantang area of the Kali Konto Watershed certainly is one of the oldest populated and cultivated areas of East Java. The earliest settlers and sawahfarmers succeeded in overcoming great odds to gain a foothold in the area which later was to become a prosperous region of wetland rice cultivation.

The earliest recorded knowledge of systematic farming in East Java is found in the Harinjing inscription of 804 AD, recording the building of a dam and the excavation of a conduit to connect the Kali Harinjing to the larger Kali Konto, just a few kilometers downstream the Selorejo dam. In 921 AD this irrigation system was reconfirmed as a freehold in favour of the descendants of the original founders of the dam and the excavated conduit. In the same area, near Kandangan, there is an inscribed stone of 1350 AD recording the restoration of the original dam of 804, which "was now so solidly reinforced that it would last forever, for all the inhabitants of the valley". Unfortunately this was not to be: the regular, often catastrophic eruptions of the nearby Kelud volcano washed the dam away many times over the centuries and even in present times the Kelud area remains a problem area for hydraulic engineers.

Present population and population trends

Presently, the upper Kali Konto watershed is an example of a very densily and overpopulated area.
The 1980 population census determined the total population of

the area in that year to be 91.300 and comparing the data with those from 1972 indicate an average annual population growth of 1.75%.[1)]

Extrapolation of the data learns that the population would be approx. 99.500 in 1985 and with unchanged trends over 125.000 in the year 2000.

The average population density, or the number of inhabitants per square kilometer agricultural land, was approx 1150/km² in 1980 (1225 for the Pudjon area, 1080 for the Ngantang area). All people live in desa's or kampongs, and although the space between the already densily packed houses still produce considerable amounts of fruits and vegetable crops or are used for animal and dairy production, the (semi)urbanized villages in the area cover 1.475 ha or 20% of the available farmland.

Table I.2. Population and population trends

		Kecamatan		
		Pudjon		Ngantang
total population	1972	38.495		45.788
	1980	44.296		47.004
	1985(est)	48.300		51.300
annual population growth			1.76 %1)	
ditto East Java			1.49 %	
population density (1980)		1.225/km²		1.079/km²
household size(persons)		4.58		4.53
residential village areas			1.475 ha (20% of total farmland)	

Source : 1972 and 1980 census.

1) presently approx. 1.0 (PKK, pers. comm.)

Agriculture

In the project area there are two major agricultural areas, each situated in a different agro-ecological zone and with different types of agricultural and cropping systems. (see also the 1:80.000 land use map; fig.I.2)

The largest single block of agricultural land in the watershed is found on the lower intervolcanic plains surrounding Lake Selorejo (the "Ngantang area"). The area, slightly over 4500 ha, is situated at elevations between 620 m (the level of the Lake) and 800 m approximately.

Large tracts of land in the Ngantang area have a continuous and abundant water supply, permitting two rice crops per year or even five crops per two years. Most rice cultivated in the area is high yielding variety rice (HYV), but lately there seems to be a renewed interest in the old traditional varieties, producing less but yielding higher market prices (better taste). Where the water supply does not permit continuous wetland rice cultivation, maize and other palawija crops are cultivated during the dry season: locally two crops of maize, locally one maize crop followed by a red pepper, sweet potato, shallot or peas/bean crop. The total area with wetland rice based cropping systems covers approximately 1.500 ha.

In the non-irrigated areas mixed perennial crop and coffee gardens are typical and the garden area seems to be increasing (presently 1200 ha). Coffee (mostly robusta but some arabusta as well) is an attractive cash crop and is often cultivated in mixed stands with many other perennials. These include coconut, clove, citrus, avocado, banana, jackfruit, durian, papaya, vanilla and a few food and vegetable crops such as cocoyam (taro). Lamtoro is often planted between the crops, providing shade to the coffee, firewood and fodder. Some gardens are almost pure coffee gardens, in others coffee is just a minor crop.

Small and more dependent farmers generally cultivate annual food crops on tegallans. In Ngantang, maize is the dominant tegallan crop, cultivated twice a year, before and after the heavy rains. Intercropping with cassava (on the ridges and edges) is common. Most of the maize cultivated is of the tall, long growing cycle type (120-130 days); the short cycle varieties do not meet the farmer's approval because they consider the yield potential to be lower.
Tobacco is an important cash crop on the tegallans on the lower slopes of the Kelud. The crop (Burley cultivars) is cultivated always in rotation with maize. The crop has been introduced fairly recently, attracted by the development of the kretek cigarette industry in Kediri.
The total area tegallan land in the Ngantang area covers approximately 2250 ha.

The second agricultural area is found around Pudjon. Situated on the upper intervolcanic plain and the footslopes bordering the plain, the area covers roughly 2.500 ha, of which approximately 1.250 ha is irrigated regularly or occasionally. At an elevation between 950 and 1300 meter, the area is separated from the Ngantang agricultural area by the south-western flank of the Anjasmoro mountain range and the north-western slopes of the Gunung Kawi.

The Pudjon area is a major vegetable growing area with cabbage, irish potatoes and carrots as main crops and onions, beans, chinese cabbage and red pepper covering smaller areas. Pudjon has an important vegetable marketing cooperative and most of the produce is sold to the towns of Surabaya, Malang and Batu. The general pattern is to cultivate cabbage and other perishable crops not too far from the central market while irish potatoes are more common on farms at larger distances. Presently there is a trend to grow more cabbage and irish potatoes,which are the most profitable crops(though more capital intensive as well). Vegetables are cultivated on both irrigated or semi-irrigated land and on tegallans. Cabbage is generally cultivated during the wet season, from February to May on irrigated land and from January to April on tegallans. Irish potato is a typical dry season crop on irrigated land (June -September). On tegallans the crop is cultivated just before and just after the heavy rains (October-January and March-June). Carrots are cultivated from January-April on tegallans and from August-December and again from November-February on irrigated land.

Subsistence crops in the Pudjon area are maize (both on sawahs and tegallans), wetland rice, cassava and sweet potatoes on tegallans, often in mixed cropping systems. The area is unsuitable for high yielding rice varieties (altitude) and all rice cultivated are traditional, tall and late maturing varieties. Maize varieties are usually tall and long cycle varieties (120-135 days), although some 80-90 days varieties are presently being introduced as well. Most of the crop is cultivated from the onset of the first rains in September till December.

Pudjon is also an important dairy area. Dairy cattle were first introduced during the early seventies and the activity is developing rapidly, as a result of favourable though artificial price mechanisms.

The cattle are kept almost permanently indoors, in small stables on the village compounds. Their nutrition is based on crop residues, supplemented by natural or cultivated (Pennisetum spp.) grass grown along road sides, irrigation channels and on the ridges and risers of terraced land. Particularly during the dry season the fodder supply has to come from the forest areas (grass, fresh leaves and twigs). With the rapid development of the dairy sector, the situation seems to run out of hand, creating heavy pressure on the forest resources and the damage inflicted is becoming a serious question indeed.

The average farm size is approximately 0.4 ha (0.37 ha in the Pudjon area and 0.41 ha in the Ngantang area), but the farms vary considerably in size, as is indicated in table I.3.

Table I.3. **Farm size distribution**

		Farm size 0.25 ha	0.25-0.5 ha	0.5 ha	total
Owners	Pudjon	34.4. %	15.7 %	13.1 %	63.2 %
	Ngantang	22.8 %	16.8 %	17.8 %	57.3 %
Owners, share croppers and tenants	Pudjon	4.0 %	2.9 %	2.2 %	9.1 %
	Ngantang	5.8 %	5.3 %	5.2 %	16.2 %
Landless farmers	Pudjon				27.7 %
	Ngantang				26.5 %

Source: PKK inception report.

Additional data on demography, population trends and agriculture in the project area will be presented in separate reports.

Agroforestry

In line with the State Forest Corporations's policy and approaches to contribute to the improvement of the living conditions of the forest communities, agroforestry projects have been set up in the project area as well. The purpose of the agroforestry systems in the project area is to allow farmers, for a restricted period during the establishment phase of the forest plantation, to cultivate annual food crops and forage crops in between the rows. In exchange, the farmer tends the forest plantation. On Java, this system is widely practiced in new teak plantations and is known under the general term of "Tumpangsari".

Tumpangsari is also practiced in the project area. Large tracts of the kirinyu scrub lands as well as in the plantation forests have been under tumpangsari. Pinus and Calliandra plantations are being established this way. Generally, each participating farmer is entitled to 0.25 ha to grow his crops for a period of two years.

The MaMa system is another, still largely experimental agroforestry system. The term MaMa comes from Malang and Magelang, the two locations where this system is being tried out. In the project area the system is applied in Pinus replantings with a rotation of 25 years. Participating farmers are entitled to a single strip of land consisting of 6 plots of 0.25 ha each. One plot may be used exclusively for foodcrops during five years. The other five plots are planted with rapid growing and intermediate tree species, and will successively be used as future agricultural plots (after 5, 10, 15 and 20 years respectively). The plot abandoned by the farmer after five years of cultivation is replanted with pinus. Presently approximately 100 ha are under the MaMa agroforestry system.

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SECTION II. THE PHYSICAL ENVIRONMENT

II.1. CLIMATE AND AGROCLIMATIC CONDITIONS

General

The climatic characteristics of the area under study are typical for the higher elevations of areas with a tropical monsoon type of climate with distinct wet and dry seasons.
Going from West to East Java, the general pattern is that of a wet season becoming shorter and a dry season becoming longer. In East Java most areas have a wet season not exceeding 5-6 consecutive months,whereby a wet month is defined as a month receiving at least 200 mm of rain (Oldeman, 1975). The dry season pattern, however, is far more complicated. The mountain complexes introduce local air circulation systems and attract orographic rainfall, resulting in a great variety of rainfall patterns at the meso- and local scale. Also the annual variation can be considerable.

In the project area, the wet season is from the middle of November to the end of March and the dry season from early June to the end of September in most years. The periods April - June and October-November are intermediate periods, during which rainy days alternate with days with bright sunshine. These periods can therefore be considered as the optimal crop growing seasons, particularly on rainfed agricultural lands. From December till March solar radiation is limited and many crops suffer from excess moisture and disease and pest incidence. In the dry season, from July onwards, soil water becomes limited and shallow rooting upland crops suffer from drought-stress, when not irrigated.

Rainfall

Rainfall data are available from a number of rainfall stations in the project area. The national meteorological service operates a station at the Selorejo dam since 1973. From 1926 to 1941, the service also recorded rainfall at the summit of the Gunung Butak (2868 meter).
Since the early fifties and sixties the DAS Brantas Project is monitoring rainfall at a number of other locations in the project area: at Pudjon on the upper intervolcanic plain (1150 m), at Kedungrejo in the valley of the Konto river (800 meter), at Ngantang on the lower intervolcanic plain (630 m) and at Sekar, close to the northwestern footslopes of the Gunung Kawi (700 meter). The data are presented in tables II.1 and II.2.

The data classify the area within agro-climatic zone C2 (Oldeman, 1975) with approximately 4 consecutive dry months receiving less than 100 mm. of rain and 5-6 consecutive wet months receiving over 200 mm. rain. Oldeman's classification is based on the cultivation of lowland (wet) rice and rainfed upland crops. Regardless the suitability of the lands for wetland rice cultivation (temperature can be a limiting factor), the rainfall pattern would permit the cultivation of one wetland rice crop, but for two consecutive rice crops supplemental irrigation would be essential. On the other hand, the rather long dry season requires a very careful management if farmers were to try year-round cultivation of rainfed upland crops, and supplemental irrigation would be very welcome to reduce the risks of crop failure. The latter is certainly valid for all agricultural areas of the watershed.

Table II.1. Climatic data national meteorological service

station: Selorejo (620 m); period 1973-1980 (excl. 1978)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature	mean	22,7	22,8	23,0	23,6	23,4	22,9	22,4	22,7	23,2	23,9	24,0	24,0	23,2
(°C)	max.	28,0	28,8	29,0	31,0	29,7	29,2	28,9	29,7	30,2	30,8	30,2	29,5	29,6
	min.	19,6	19,8	19,3	19,0	18,6	17,5	17,5	17,0	17,6	19,0	19,1	19,5	18,6
Evaporation(pan A) (mm/day)		3,16	3,47	3,74	4,11	4,17	4,77	5,29	6,11	6,37	6,02	4,90	3,83	1704
Hours of sunshine/ day		3,08	3,21	3,60	4,46	5,14	6,06	6,16	6,19	5,59	4,60	4,14	3,71	1700

station: Gunung Butak (2868 m); period 1926-1941

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall (mm)	440	393	353	235	130	78	54	19	18	25	148	290	2183

Table II.2.:

Rainfall data Kali Konto project area (source: DAS Brantas)

Ngantang Agricultural area

	Ngantang (630 m)			Sekar (700 m)		
	Mean monthly	S.D.	Mean Max.daily	Mean monthly	S.D.	Mean Max.daily
Jan	500.2	184.0	71	508.8	150.4	70
Feb	413.0	134.8	69	435.2	109.3	73.5
Mar	393.1	166.8	54	426.7	108.3	69
Apr	212.6	118.3	38	258.9	127.6	48
May	158.3	101.8	32	180.2	109.8	37
Jun	52.0	60.4	15	71.3	76.9	22
Jul	50.8	79.8	15	49.5	61.6	15
Aug	34.0	54.4	8	28.1	37.3	8
Sep	39.5	50.3	13	32.0	52.0	9
Oct	150.4	116.9	28	108.1	99.6	37.5
Nov	195.0	93.5	42.5	263.5	123.6	53
Dec	356.8	142.4	56.5	387.9	143.6	49.5
Total	2555.7	602.2	-	2737.3	524.7	-
	period 1950-1982			period 1950-1978		

Pudjon Agricultural area

	Pudjon (1150 m)			Kedungrejo (800 m)		
	Mean monthly	S.D.	Mean Max.daily	Mean monthly	S.D.	Mean Max.daily
Jan	392.9	158.1	58	489.7	206.4	62
Feb	354.8	130.9	55	393.3	199.6	50
Mar	310.7	90.5	50	344.1	169.0	45
Apr	156.0	78.1	38	159.8	115.2	35
May	114.8	69.7	30	125.7	86.6	34.5
Jun	49.3	49.8	13	55.0	75.1	17
Jul	50.6	72.2	16	42.7	102.2	15
Aug	32.6	37.9	12	23.6	36.1	5
Sep	42.0	62.9	9	37.6	73.5	7.5
Oct	115.3	103.3	33	119.8	138.8	20
Nov	217.9	129.9	43	209.3	122.4	40
Dec	308.0	92.0	43.5	337.1	146.0	47.5
Total	2144.9	463.4	-	2320.6	681.6	-
	period 1950-1982			period 1960-1978		

However, the value of the rainfall data and the climatic classification is limited in a regional sense. The distribution of rainfall in the highlands of tropical areas is the result of the combined effects of

- macroscale air circulation and the movement of the Inter-Tropical Convergence Zone
- local air movements in which the orographic (vertical)component of ascending air masses influences pluviosity
- exposure and orientation in relation to the mountain complexes and the sea (rainfacing and rainshadow zones).

The influence of the vertical component (the orographic effect) in the project area is considerable, but as there are no rainfall stations on the slopes of the major volcanic complexes, this effect is still largely unknown.
Investigations in similar tropical areas (H.Trojer, 1976) indicate however, that the valleys and highest mountain crests generally receive less precipitation than the mid-sections of the slopes (the effect of the vertical component of the local circulation).
The exposure factor is equally important. Foresters working in the area during the early years of the century noted already that the Southern and Western slopes of the mountain complexes receive more rainfall than the Northern and Eastern slopes (the stemming effect). They also noted a remarkable difference in the natural vegetation between the rainfacing sides and the leeward sides of the mountains.
An additional aspect of the vertical component is its influence on rainfall distribution and intensity. Mid-sections of the major slopes often have a more regular distribution of rainfall over the year and at the highest peaks, above 2000 meter, rainfall intensity may be considerably less as a substantial part of the precipitation occurs in the form of drizzle and light showers (see rainfall data Gunung Butak, table II.1.).

Considering the above, it can be said that the available rainfall data have a limited value for the forest areas. Concerning the agricultural areas, where all the meteorological stations are situated, the data permit the following tentative conclusions:

- The Ngantang area receives approx. 20-30% more total rain than the Pudjon area, as the latter is situated more or less in the rainshadow of the Kawi.
- there is no significant difference between the two areas in respect to the length and intensity of the dry season.
- the higher annual amounts of rain in Ngantang are due to a wetter rainy season; in the peak of that season (January - February) the average monthly rain is around 450 mm in Ngantang, against 375 mm in Pudjon. As the evapotranspiration in Ngantang is also higher (temperature), the effects will be limited.
- rainfall intensity in Ngantang is higher than in Pudjon (per 24 hrs, confirmed by other data of Proyek Brantas).
- within the Ngantang area, the lower slopes of the Kawi (Sekar) receive more rain than the area North of the Lake.
- within the Pudjon area, it is likely that the lands on the lower slopes of the Kawi, south of Pudjon, receive less rain than the area north of Pudjon.
- the annual variation in rainfall in the dry season is considerable; in some years there may be no rain at all during this period while in other years a real dry season is hardly noticeable.

Soil moisture balance and moisture regimes

The availability of soil water in a free drained upland soil with groundwater tables far below the reach of plant root systems, as is the case in all upland soils of the project area, is a function of rainfall, evapotranspiration and the capacity of the soil to store and release water in the rooted zone (the actual available moisture capacity of the soil).

With these data, the soil moisture balance has been calculated according to Thornwaite and Mather (1955), for a small number of locations and representative soil types.

The empirical method is based on mean monthly values, so in drier or wetter years the actual situation will be different from the calculated model.
Since evapotranspiration data are not available, they have to be calculated according to a method developed by Penman (ILRI, 1972). The method requires data on temperature, air humidity, coefficients of sunshine, wind speed and solar radiation at the outer limit of the atmosphere. Several of these parameters also have to be estimated, but the calculated approximate evapotranspiration values for Ngantang are in agreement with data from other similar locations on Java (Irish, 1979). The calculated total mean annual potential evapotranspiration at Ngantang is around 1500 mm, 1350 mm at Pudjon and approx. 825 mm at the summit of the Kawi mountain.
The water retention capacity at different tensions of the soils have been determined in the laboratory on undisturbed soil samples; samples were collected from each major soil horizon between the soil surface and the 120 cm depth. The actual available moisture capacity is calculated, based on a rooting depth of 50 cm in the agricultural soils and 120 cm in the forest soils.

The calculated waterbalance for four selected locations and major soil types typical for the selected location are presented in fig.II.1 and an example of the calculation is presented in table II.3.

The waterbalances indicate that a representative tegallan soil in the Ngantang area will be unable to supply soil water to a crop with a rooting depth of 50 cm as from the third week of July approximately in an average year. For a tegallan soil in the Pudjon area (Pudjon series) this occurs around the first week

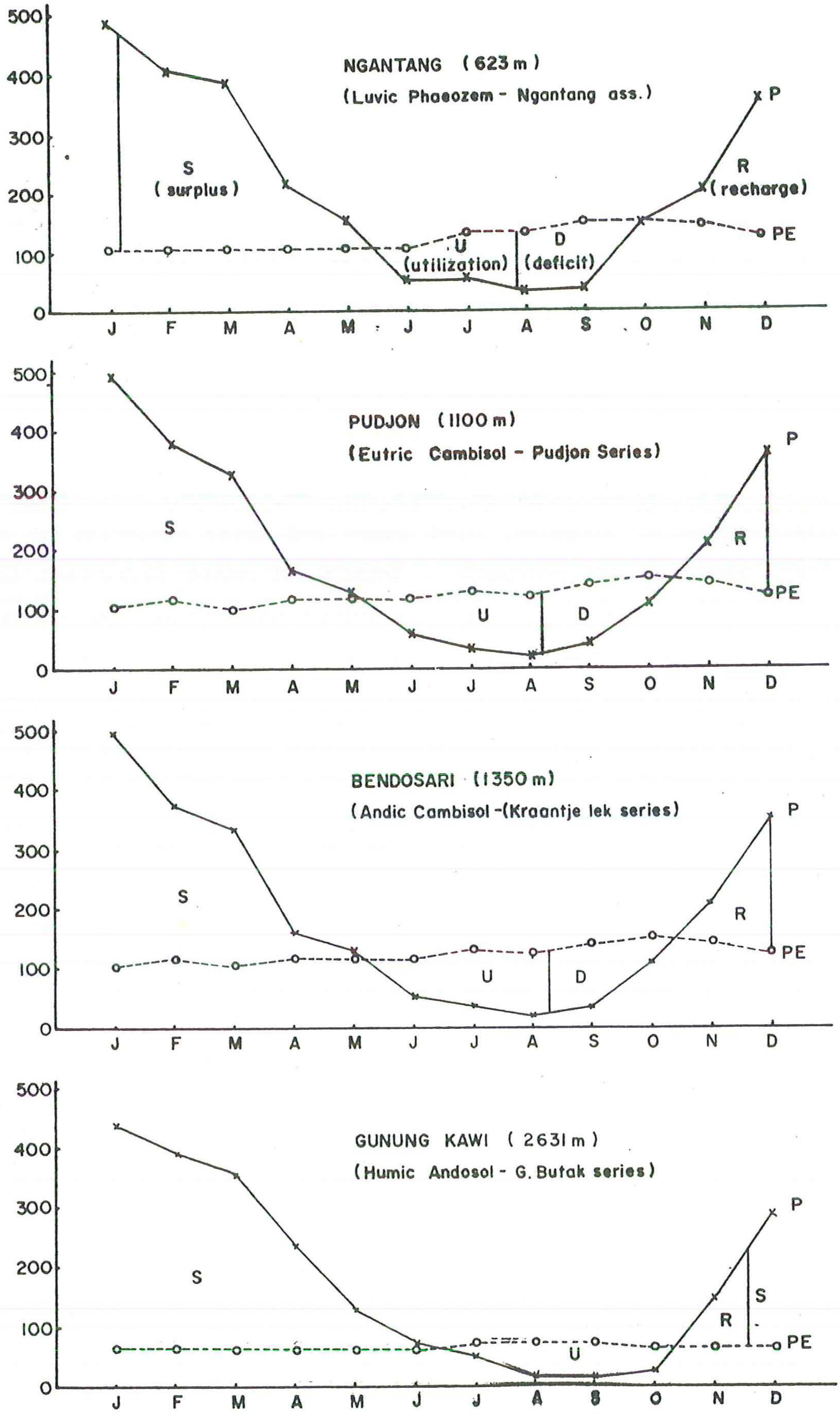


Fig. II.1. Soil moisture balance of four representative sites and soil types in the Kali Konto Watershed.

Table II.3. Calculation of the Soil Moisture balance acc. to Thornwaite and Mather

Location : Ngantang (630 m)

Soiltype : Ngantang Series (Luvic Pheozem)

STo = 162 mm (moisture retention at field capacity 00-60 cm soil)

	J	F	M	A	M	J	J	A	S	O	N	D	Year
P	500	413	393	212	158	52	51	34	39	153	195	360	2560
PE	108	117	105	117	120	117	132	129	141	150	141	123	1500
P - PE	392	296	288	95	38	-65	-81	-95	-102	3	54	237	1060
APWL						-65	-146	-241	-343				
ST	162	162	162	162	162	108	66	36	19	22	76	162	
Δ ST						-54	-42	-30	-17	+3	+54	+86	
AE	108	117	105	117	120	106	93	64	56	150	141	123	1300
D	0	0	0	0	0	11	39	65	85	0	0	0	200
S	392	296	288	95	38	0	0	0	0	0	0	151	1260

(all data are in mm)

P = precipitation

PE = potential evapotranspiration

P-PE = difference

APWL = accumulated potential water loss

ST = storage : when P > PE ST = P-PE + storage last month

when P < PE ST = $STo.e^{\left(\frac{-APWL}{STo}\right)}$

STo = moisture content rooted zone at field capacity (= 162 mm)

AE = Actual evapotranspiration : when P > PE AE = PE

when P < PE AE = P + ΔST

D = Deficit = PE - AE

S = Surplus, only when S > STo (ST-STo)

of August and for the tegallans on the lower slopes of the Kawi/ Anjasmoro (Kraantje Lek series) about a week later.
The soils at the summit of the highest mountains never show a deficit.

Soil moisture is equally an important parameter for the classification of soils in the US Soil Taxonomy. The system defines a soil moisture control section, which is between 10-30 cm in most loamy and clayey soils as found in the area. Calculating the water balance of this control section indicates the section to be dry between 60-90 days (cumulative) per year. This would classify most soils as having an "Udic" soil moisture regime. (Soil Taxonomy, 1975)
A subdivision of the several soil moisture regime classes has been proposed recently (van Wambeke, 1982). According to these proposals, the soil moisture regime of most soils would be Dry Tropudic, i.e. with a soil moisture control section dry for more tan 30 but less than 90 consecutive days.

Temperature and Soil Temperature Regimes

The survey team was unable to collect reliable temperature data of the area. The only meteorological station recording temperature is the Selorejo station at the dam, situated at the lowest point of the project area. It is likely, moreover, that the presence of the lake will have an effect on the temperatures recorded at the station. The data are presented in table II.1.
Another station with systematic temperature data is the agrometeorological station at Tlekung, near Batu, approx 12 kms Southeast of the watershed and situated at an elevation of approx 950 meter. It is unfortunate however that the Stevenson hut is not well placed and that the data can hardly be used for extrapolation.

Another approach is the application of the formula of Braak (Braak, 1928): $T = 26.3 - bh$, with $a = 26.3°C$ (the average temperature at sealevel), $b = 0.006$ and h the elevation above sealevel (in meters). It is interesting to note that the calculated mean annual temperatures of most stations of East Java are always approximately 0.7-0.8°C lower than the recorded temperatures. This may be explained by the drastic changes occurring in the ecological balance of the island over the last fifty years. The dwindling forest resources (acting as a coolant) and the rapidly increasing urban areas (heating effect) may well be the origin of the discrepancy between the recorded and calculated mean annual temperatures. Allowing for this effect, the calculated mean annual temperatures of the Pudjon agricultural area would be around 20.4°C, decreasing to 9.8°C at the top of the Gunung Butak at 2860 meter.

An important aspect is also the daily temperature fluctuation. It is well known that temperatures in the area can drop to very low values during clear cloudless nights in June and July. Night-frosts at the summits of the highest mountains are common during this period. The effect ("cold föhn") is influenced by dry cool (winter) air coming from the Australian continent and the local air circulation from the higher elevations.

Soil temperature is one of the parameters to classify soils in the US Soil Taxonomy. Tentatively three different soil temperature regimes have been established in the area :

- the isohyperthermic soil temperature regime ($>$ 22°C) of the soils below approximately 900 meters
- the isothermic soil temperature regime (15-22°C) of soils between approx. 900 and 2000 meter and
- the isomesic temperature regime (8-15°C) for the soils above approximately 2000 meter.

Soil temperature is defined as the mean annual temperature at 50 cm below the soil surface (Soil Taxonomy, 1975).

II.2. GEOLOGY AND VOLCANISM

General

The geology and geomorphology of the area are the result of widespread volcanic and orogenic activity, alternated by periods and cycles of denudation.

The area is situated in the Solo Zone, a longitudinal volcanic area between the Tertiary geanticline of the Southern limestone hills (South of Karangkates) and the geosyncline of Northern Java (the Rembang hills and Madura). The zone is filled and capped by a series of giant quarternary volcanoes and intervolcanic plains.

The Anjasmoro mountain range is the oldest volcanic complex in the area. van Bemmelen (1949) provisionally considers the mountains to be formed during the Upper Pleistocene, though others consider the range to be formed somewhat earlier (Middle Pleistocene). The base of the Anjasmoro range consists of extensive and thick layers of basaltic and intermediate lava flows (also known under the name of the Jombang layers), covering the older rocks and sediments of the southern and northern tertiary geanticline and geosyncline respectively. The layers are the result of fissure eruptions but on top of the flows a number of volcanic cones developed. Due to faulting and folding, the Anjasmoro volcanoes broke down in a number of irregular blocks. The Luksongo hills are probably the most Western blocks of the range.

Next in age is the Arjuno (3329 m), situated North of the area. Due to the enormous weight of the volcano on the underlying soft sediments, the Arjuno cone broke off, resulting in renewed volcanic activity along the rifts and ridges (the Welirang group, presently in a fumarole and solfatara stage).

The twin volcanoes Butak (2868 m) and Kawi (2631 m) belong to a group of younger, holocene volcanic structures which partly cover and mask the older upperpleistocene complexes. The Kelud is the youngest in this range and still active.

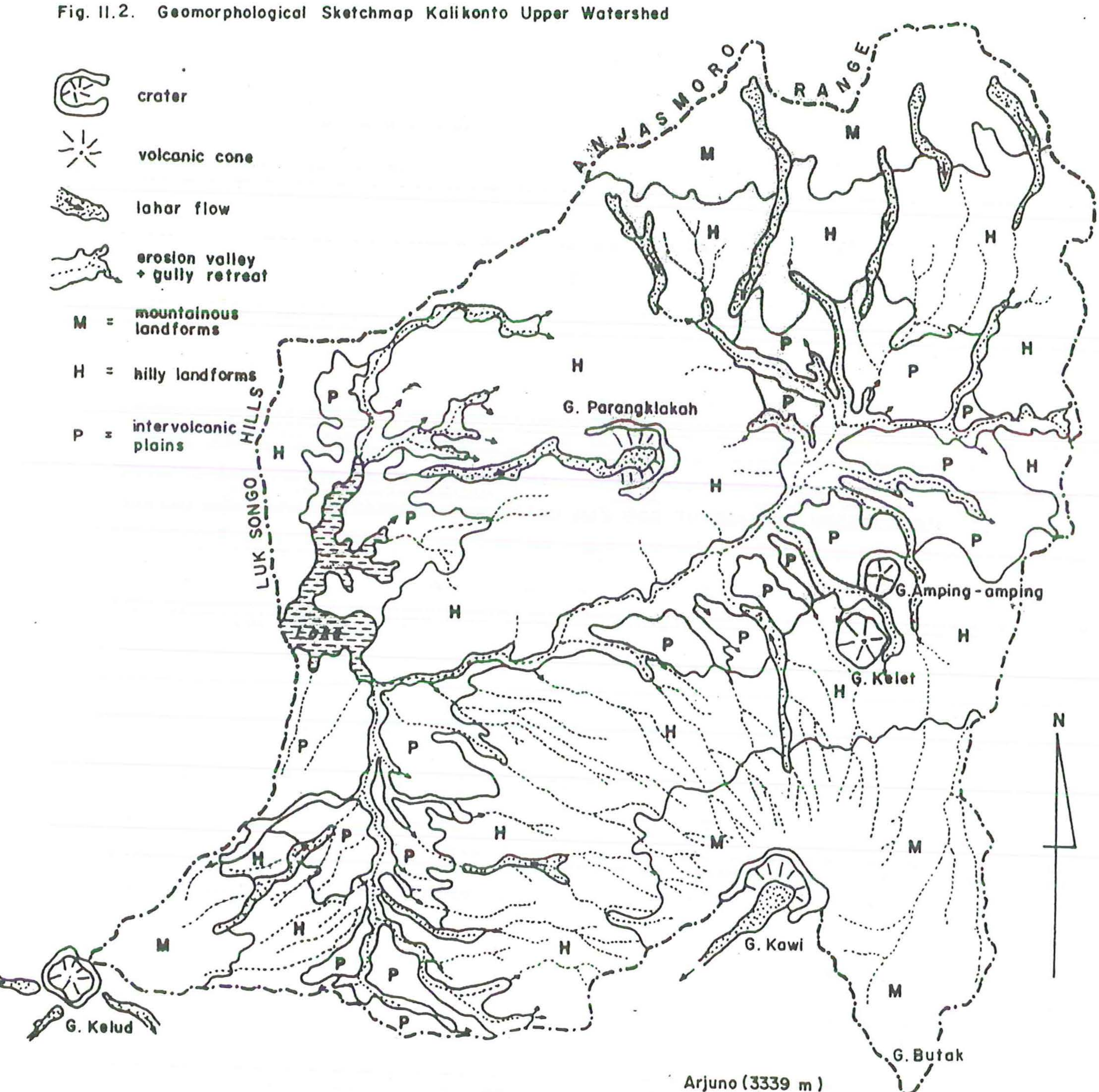
The geologic-geomorphologic sketchmap (fig II.2) and the schematic section accros the Arjuno, Anjasmoro and Kawi-Butak complexes (fig II.3) clearly indicate the volcanic-tectonic structure of the area.
From the figures we see that there are a number of volcanic complexes, some small and hardly visible as such, others large and imposing, but all having their particular influence on the landform and soil conditions of the area.

The Kawi-Butak Complex

The twin volcanoes Kawi (2631 m) and Butak (2868 m) are presumably situated on a small N-S transverse fault. The complex is of the "strato-volcano" type, consisting of successive and overlapping shields and layers of andesitic rocks, breccias, agglomerates and tuff (consolidated and cemented pyroclastic and lahar materials) and ash. Alternated resistent and less resistent layers favour the formation of steepsided valleys and undercutting of less resistant layers give rise to the formation of waterfalls. The Coban Rondo fall is just one of them; several more have been found as well.

The two volcanoes are linked by a "saddle" of sloping land at elevations between 2000-2600 meter. Although both volcanoes are considered extinct, the Butak is probably younger than the Kawi. The cone of the latter is strongly dissected by radial, extremely deep and steep ravines with sharp edges and crests (serrated landforms). The Kawi also has a well formed and deep crater, which is open towards the south-west, as a result of the collapse of the crater rim. The northern rim of the crater is part of the watershed boundary.

Fig. II.2. Geomorphological Sketchmap Kalikonto Upper Watershed



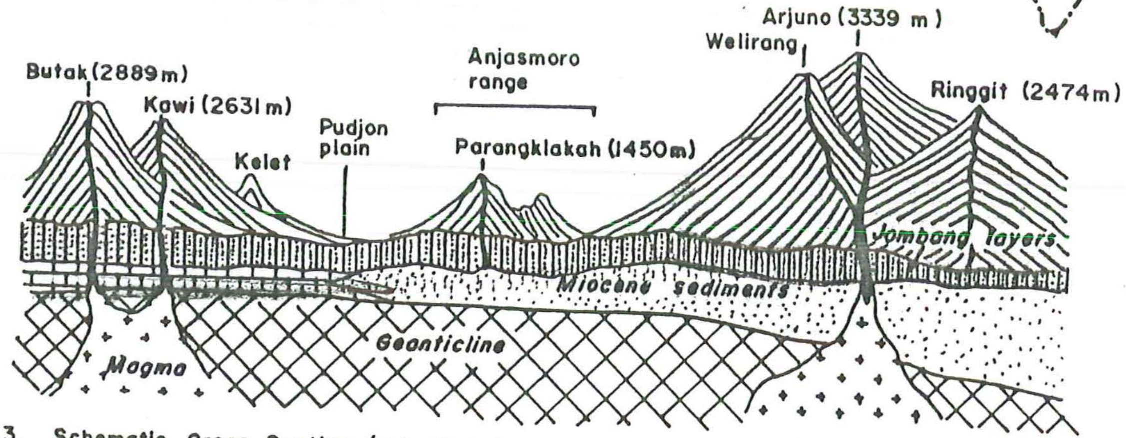


Fig. II.3. Schematic Cross Section (adapted from van Bemmelen, 1937)

The Anjasmoro, Parangklakah, Kelet and Amping-Amping

As described already, the Anjasmoro mountains are remnants of the oldest volcanic activity in the area. It is possible that the range was formerly a single dome-shaped mass, reaching about 1500-1700 meter at the highest points. Erosion has cut deep into the volcanic (andesitic) pile, leaving an irregular hilly mass (planèze or the residual stage of dissection).

One of the old Anjasmoro craters is the G. Parangklakah, situated within the project area and with a highest peak of 1490 meter. The rim of the almost perfect circular crater is still well intact. The western section of the rim collapsed, possibly under the weight of a crater lake. The collapse of the crater wall and the emptying of the lake resulted in a huge lahar flow of mud, volcanic debris, blocks and boulders, which covered the lower intervolcanic plain (see fig.II.2).

The Kelet and the Amping-Amping are two smaller volcanic cones situated on the intervolcanic plain of Pudjon.
The Kelet (1477 m) is a single lava eruption cone, build up from andesitic rocks. The smaller Amping-Amping (1266 m) is a volcanic spatter or cinder cone, consisting mostly of loose cindery volcanic material. Both cones are covered by thin covers of volcanic ash.

The Kelud

The Kelud volcano (1731 m) has over the centuries brought both prosperity and tragedy to the region: prosperity in the form of regular volcanic ashes enriching the surrounding lands and tragedy as a result of violent eruptions, hot and cold lahars and periodic floods creating havoc in populated areas.

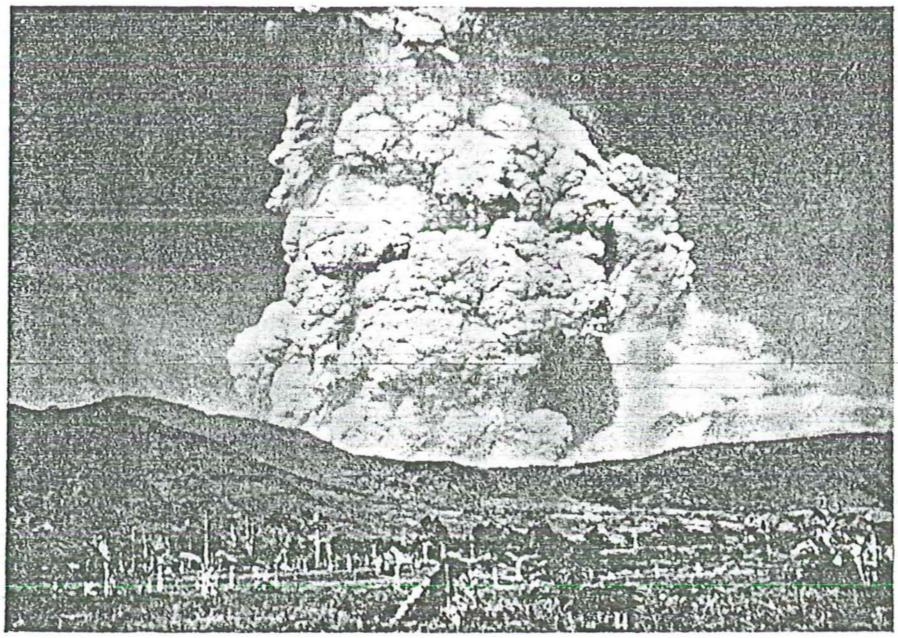
The notoriety of the Kelud is due to the viscosity of the extruding magma, which tends to form an impermeable plug or dome in the crater pipe. Rainwater fills the crater and a crater lake results. Eruptions generally start with the formation of a steam pillow at the bottom of the lake produced by increasing heat and mounting pressure from below the plug. When the eruption takes place, the whole lake is ejected. A cold lahar mud and boulder stream will run down through the ravines, soon followed by hot lahar formed by the hot deeper water layers of the lake. The lahars have an enormous erosive power and make deep incisions in the U-shaped ravines. Most of the lahar valleys are found on the southern and western slopes of the Kelud, outside the project area. The small Kali Laharkelet on the Kelud's northeastern slopes and within the project area probably is an older lahar ravine, covered and smoothened by airborn pyroclastic materials and no longer recognizable as an active lahar valley.

After the lake has been thrown out, the disintegrated pumice plug, together with debris from the inner slopes of the crater are ejected, often mixed with ash, steam and glowing volcanic gasses (ladus). When also the pumice plug has been blown out, the crater pipe is "clean" and the eruption continues ejecting mostly ash.

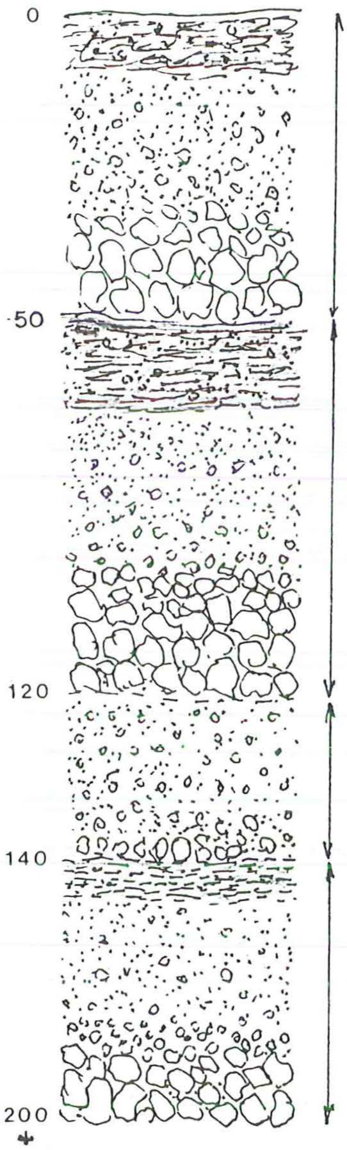
The earliest known Kelud eruption is of 1000 AD. Between 1311 and 1481 nine eruptions were recorded, the most interesting one occurring in 1334, which was identified as a "banyu pindah" in the Pararatan inscriptions. Banyu pindah, moving water, is an apt description of the hot lahar streams. More recent eruptions occurred in 1811, 1826, 1835, 1848, 1864, 1901 and 1919. In 1875, the crater wall collapsed, resulting in a flood, which destroyed 1579 bahus of sawah, 790 bahus of tegallan and 1451 homes. The 1919 eruption killed over 5000 humans and destroyed 104 villages, all in a time span of 45 minutes.
After the catastrophe of 1919, the Government decided to drain the lake by a number of tunnels; the tunnels are found at the Blitar side of the mountain. The next eruptions, in 1951 and 1966, caused significant less damage than usual, but the eruptions also

destroyed the tunnels. A new set of seepage pipes was then constructed which, while not actually reaching the crater lake, would drain it, as if the rocks were permeable. Zen (1967) reported that the pipes failed to drain the lake properly, so lahars are again a potential danger.

The history of the Kelud eruptions is perfectly reflected in the soil conditions of the area. All soils on the slopes of the Kelud are formed in stratified and alternating layers of coarse and fine pumice and ash. On the footslopes, the pumice layers are generally thin, the pumice particles small and ash (sandy ash) predominates. Moving to the top, closer to the source, the thickness of the pumice layers increases, and ash no longer predominates. A schematic profile of a representative soil of the Gombong Association, found on the middle slopes of the Kelud, is presented in fig.II.4.



Kelud eruption of 31 August 1951
(from: Mohr, et.al. Tropical Soils)



I — most recent deposits, probably of the 1919 or 1901 eruptions(?); profile is formed in coarse pumice gravels (fragmented plug), becoming gradually smaller in size and changing into sandy ash towards the soil surface. The topsoil has a well developed A horizon with 3-4% organic matter.

II — a buried profile, representing a major eruption cycle; the sequence of pumice gravels and ash is similar, but most layers are thicker; the buried topsoil has a well developed A horizon with 5-6% organic matter

III — a small eruption cycle, mostly consisting of fine and medium sized pumice with some sandy ash on top; soil has had little time to develop an A horizon

IV — a 60 cm thick buried profile representing a major eruption cycle (see II)

Figure II.4. Schematic profile of the middle slopes Gunung Kelud (850 m; 4 km NE from crater).
Gombong association: Umbric Vitrandept, medial over cindery, isohyperthermic. (Vitric Andosol)

Spatial distribution and composition of volcanic ejecta

It is well known that during volcanic eruptions the coarsest ejecta will be deposited not too far from the source and that the finest ash particles will be blown high in the atmosphere and fall slowly as an ash rain covering extended areas. The distance the particles will travel will depend on their size, shape, specific weight and the prevailing winds.

Coarse volcanic ejecta found in the area of study are limited to pumice gravels, originating mainly from the fragmented plug or dome found at the top of the magma pipe in the Kelud crater. Volcanic bombs, lapilli and other rock type ejecta have not been found in the area.

Research carried out by students from Universitas Brawijaya on the spatial distribution of pumice gravels on the Gunung Kelud showed that the size of the individual pumice gravels indeed decreases with increasing distances from the crater; also the porosity of the pumice gravels increased. Within 3 km from the crater, the relative amounts of pumice in the size fraction of over 5 cm varied from 10-25%. In the zone between 3 and 6 km there was no gravel of this size fraction and beyond 6 km almost all pumice was smaller than 2 cm. More important, however, is the relation between the amount of gravels and the distance from the source. The thickness of the pumice layers generally decreases with increasing distances from the crater. However, some layers actually appear to be local and in the form of lenses. The latter was also observed by the survey team on the tegallans of the Ngantru village on the lower slopes of the Kelud. In this area, the amount of pumice gravel in the topsoil varies considerably over short distances, giving the idea as if the intensity of the "gravel rains" varied from one spot to another. The phenomenon may have been caused by local air tubulances during the eruption.

The influence of the Kelud can be traced all over the western (Ngantang) part of the project area. Comparing the soils of the Ngantang area with those of Pudjon, the presence of coarse sand particles in all soils of the Ngantang area is striking. A close look shows that most of the sand particles are actually pumice fragments. The influence is also found on the western slopes of the Kawi facing the Kelud, but only below the 800-850 meter contour line. Above this line all soils are virtually gravel and sand free, as is the case on the northern Kawi slopes. Also the soils in the Pudjon area are gravel and sand free, with the exception of the soils on some slopes of the Anjasmoro range where many soils have some fine pumice gravel layers in the deeper subsoils (around Ngebrong for example). Studying the position and exposure of these pumice layers, the team reached the conclusion that these are much older and possibly originate from the older Anjasmoro eruptions or from the Arjuno group.

More difficult is it to trace the origin of the different ashes. Most of the Kelud ash of the 1901 eruption was blown to the west (dry monsoon). The 1919 ash was blown to the east and west; the west monsoon blew most ash to the east, but the ash which reached the stratosphere was blown west (anti-passate winds).

Baak (1949) studied the mineralogical composition of the 1919 Kelud ashes, collected from several locations. The ash was of an augite -hyperstene andesitic origin. Some of Baak's data are presented in tables II.4 and II.5. He found a distinct increase in the SiO_2 content of the ash with increasing distance from the source (volcanic glass being the main component in the finest ash). Pyroxenes were generally confined to the coarse ash fraction and are thus found particularly close to the source. Near the Kelud the plagioclase was found to be richer in calcium and poorer in sodium. This also confirmed by the results of the soil survey (soil sample analysis).

Table II.4. Mineralogical composition of the sandy fractions of some volcanic ash samples of the G. Kelud (after Baak, 1949)

Km from crater - = West + = East	Fraction	percentages of minerals							
		Opaque	Volcanic glass	Rock frag - ments	Plagio- clase	Augite	Hyper- sthene	Green Horn- blende	Oxy- horn- blende
- 9	200-500	5	7	27	46	7	8	-	-
	100-200	3	20	16	46	7	8	-	-
	50-100	4	35	10	49	1	-	-	1
	20- 50	1	85	4	10	-	-	-	-
- 92	100-200	3	84	-	11	1	1	-	-
	50-100	1	52	1	35	3	7	1	-
	20- 50	2	82	-	12	1	3	-	-
- 360	50-100	12	46	2	38	-	2	-	-
	20- 50	4	86	-	9	1	-	-	-
+ 36	200-500	4	-	23	47	9	17	-	-
	100-200	17	15	8	45	8	7	-	-
	50-100	9	25	14	42	3	7	-	-
	20- 50	4	73	7	14	-	2	-	-
+ 66	200-500	-	56	7	35	1	1	-	-
	100-200	1	39	14	41	4	1	-	-
	50-100	8	47	5	37	-	3	-	-
	20- 50	1	84	-	15	-	-	-	-
+ 166	100-200	10	80	-	7	1	2	-	-
	50-100	4	42	2	45	2	5	-	-
	20- 50	1	84	-	13	1	1	-	-

Table II.5. Total chemical analysis of volcanic ash of the G. Kelud (after Baak, 1949)

Distance from crater (km)	1	2	3	4	5	6	7
(- = W; + = E)	-36	-9	-5	rock	+36	+56	+166
SiO_2	60.8	54.8	52.6	57.6	54.6	57.0	59.9
TiO_2	0.6	0.6	0.9	0.6	0.7	0.9	0.6
P_2O_5	0.2	0.2	0.2	0.1	0.2	0.	0.3
Al_2O_3	18.3	20.6	17.2	18.0	20.7	17.8	18.6
Fe_2O_3	3.9	4.5	3.9	3.9	4.9	4.3	3.7
FeO	2.4	3.8	5.9	3.9	3.3	4.1	2.2
MnO	0.2[1]	n.d.	0.1	0.2	0.3[1]	0.1	0.3[1]
MgO	1.9	3.3	4.4	3.1	3.2	2.6	2.0
CaO	6.0	8.5	10.2	8.5	8.8	7.8	6.4
Na_2O	5.9	3.0	3.1	3.1	2.9	3.6	3.9
K_2O	1.0	0.5	1.1	0.8	0.5	1.1	1.0
H_2O+	1.0	n.d.	0.4	tr	0.6	0.5	1.5
H_2O-	n.d.	n.d.	0.1	0.3	n.d.	0.1	n.d.
SO_3	0.2	0.2	0.2	n.d.	0.2	0.3	0.4
Niggli values							
si	206.0	153.0	134.0	168.0	150.0	172.0	200.0
al	36.5	33.5	26.0	31.0	33.5	31.5	36.5
fm	26.5	32.0	37.0	32.0	31.5	30.5	26.0
c	22.0	25.5	27.5	26.5	26.0	25.5	23.0
alk	15.0	9.0	9.5	10.5	9.0	12.5	14.5
qz	+ 46	+ 17	- 4	+ 26	+ 14	+ 22	+ 42

1 = Mn_3O_4

Although Baak demonstrated that each volcano has its own characteristic and specific mineralogical association, it is also known that the ash composition of a particular volcano may vary from eruption to eruption. Also the fact that ashes can travel far, complicates the situation. Pudjon, for example, at 20 km from the Kelud, received 15 cm of Kelud ash in 1919 and 5 cm in 1951, but the area also received 3 cm of ash from the Gunung Agung (Bali) in 1963 and a student collected 2 mm of ash at Coban Rondo from the 1982 Galunggung eruption (West Java).

As no other mineralogical data are available of the soils in the project area, it is difficult to indicate the origin of the ash and the distribution of the different ash types over the area. However, analyzing the analytical laboratory data of the collected soil samples, the following can be said:

- the ashes on the northern slopes of the Kawi are acid and low in weatherable minerals. Base saturation of soils of the area (G.Butak and Coban Rondo Series) are very low, in spite of the fact that the soils are situated on the dry leeward side of the Kawi,
- the ashes of the Anjasmoro, and the western slopes of the Kawi are higher in weatherable minerals,
- the ashes of the Kelud are higher in calcium, but often low in potassium or have a mineralogical composition resulting in unfavourable Mg/K ratios.

II.3. HYDROLOGY

Information and data on the hydrological and hydrogeological conditions of the Kali Konto watershed are scarce. Only fairly recently and in connection with the construction of the Selorejo dam, DAS Brantas started to measure flowstreams at a few sites within the catchment. The measurements are part of a study on reservoir sedimentation and sediment transport, which is a severe problem, causing loss of valuable water storage capacity and threathening the effective life of the reservoir. High rates of sedimentation indicate the magnitude of accelerated erosion in the watershed. This aspect will be discussed separately in Section V.

The project area is made up of three catchments: the Kali Konto with a catchment area of 13.700 ha., the Kali Kwayangan of 5.300 ha. and the Kali Pinjal of 4.300 ha. The three catchment areas meet at Lake Selorejo.

Each stream has its particular characteristics and longitudinal profile.
The Kali Konto shows an interrupted profile of a stream with several stretches along its course with nickpoints being the headward limits of successive periods of base leveling. The upper section is young and active, with V-shaped cross profiles and advancing headwards to the higher areas. The middle section has a steepened stream gradient and the river has cut itself deep in the volcanic materials, running fast in a narrow U-shaped valley. The lower section has more of a graded stream in a system of quasi-equilibrium, streaming in a concave, colluvial valley.
The regimes of the Kali Pinjal and Kali Kwayangan are different. They have young and active upper-sections, advancing headwards and laterally and graded lower sections.

Streamflow, measured at Selorejo from 1951 to 1972, averaged from 5-7 m^3/sec during the period July-October and 14-17 m^3/sec from

January to March. The highest mean monthly value measured was 33 m^3/sec in February 1960, the lowest 3.1 m^3/sec in October 1964 and 1965.
The data recorded clearly illustrate the influence of the dry season and the relatively long period of two months necessary to recharge the aquifer and for the baseflow to return to normal levels. The data also show that the flow during the dry season is well correlated with the total rainfall of the preceeding rainy season. As the wet seasons in the Ngantang area are approx. 20% wetter than in the Pudjon area, the relative streamflows in Ngantang may likely be higher as well.

The thick packages of volcanic sediments covering the watershed act as the main aquifer. The loamy textured volcanic ash and the soils developed in these materials are very porous, have a high permeability and are thus excellent waterholders. Weathered and rotten andesitic rock, as well as sorted coarse pumice also produce good waterholding media. On the other hand, compacted and somewhat cemented volcanic breccia and conglomerates are less good water-holders and volcanic tuff (consolidated and cemented ash) is a poor waterholder in spite of its porosity being high.

Generally speaking, the upper slopes of the volcanic complexes of the studied area tend to be very porous. Their permeability is so high that no run-off occurs, even on the very steep slopes; as a result no well defined stream channels exist in that area. Somewhat lower on the slopes the porous materials alternate with less permeable layers and springs or surface seepage occurs. Most of the springs in the area are found at the contact between the permeable volcanic ash layers and underlying tuff, or beds of breccia's and conglomerates (buried and cemented lahar materials). They also occur below the outcrop of well sorted pumice layers overlying less permeable tuff or compacted ash. Students doing field work in the area demonstrated that pumice layers are important

and extremely good conduits of subsurface water.
Many springs disappear during the dry season and only the ones associated with larger flowpaths are permanent. The influence of the dry season is well illustrated by the long period necessary to recharge the aquifer in the volcanic sediments; for the base flow to return to its normal level two wet months are normally required; these data are in line with data from other volcanic areas on Java (Bruynzeel, 1983).

Downstream of the springs there is simple stream erosion and basal sapping by the streams causes steepening of the headwall and gully retreat. On strato-volcanoes, like the Kawi, the structural control of hard lava or tuff beds will commonly lead to steep-sided (gorge-type) valleys. Alternate resistent and less resistent beds are especially favourable for the development of waterfalls as the non-resistent beds are undercut. Headward erosion develops the small falls into bigger ones such as the Coban Rondo fall and other falls found on the northern and western slopes of the G.Kawi as well as in the Anjasmoro mountains.

The lack of quantitative data on flowstreams, aquifers, available irrigation water and waterconsumption is unfortunate and requires urgent attention.
This is particularly true as the lack of sufficient irrigation water during the dry season appears to be a limiting factor and in some areas even the most limiting factor for agricultural development. With the degrading and dwindling forest resources, affecting the hydrological function of the forest lands, this trend is likely to continue and to become more serious.
The soil survey team has found areas with soils strongly modified by long periods of irrigation and wetland rice cultivation, but which are no longer irrigated because of the unavailability of irrigation water. Farmers reported about springs being dried up permanently (PKK, pers. comm.).

Although the statistics indicate that the total area irrigated does not decrease, it is likely that over the years a greater portion of the lands only occasionally receives irrigation water.

II.4. PHYSIOGRAPHY AND LANDFORMS

Landform maps

As the soil survey of the project area was commissioned only in November 1982, at a time there was already a pressing need for early results and data on landforms, slopes, soils and erosion of the area, the soil survey team prepared first a physiographic landform map at a scale 1:20.000, based on aerial photointerpretation, supported by field data. The map is not included in this report. The accompanying descriptive legend includes tabular descriptions of the twenty (20) landform units recognized, their subdivision in smaller units based on slope characteristics, erosion, soils, drainage conditions and landuse practices such as terracing and irrigation for wetland rice cultivation. In July 1983, the map and report were presented as a working document for the agronomy, forestry and vegetation specialists and land use planners working in the area. Copies of the map and report are available.

The 1:20.000 landform map has been the basis for the 1:50.000 generalized landform map attached to this final report (map 2A). Figure II.5 is a reduction of the generalized map ; not to scale.

Reviewing the area, four different main landscapes can be recognized:

- the alluvial and lahar valleys (4.5% of the area)
- the intervolcanic plains and plateaux (25.3%)
- the hilly areas (49.3%)
- the volcanic mountainous complexes (19.7%)

They are described as follows:

Alluvial landforms

The alluvial landforms are limited to the generally narrow alluvial and colluvial valleys, U-shaped or concave and without terraces.

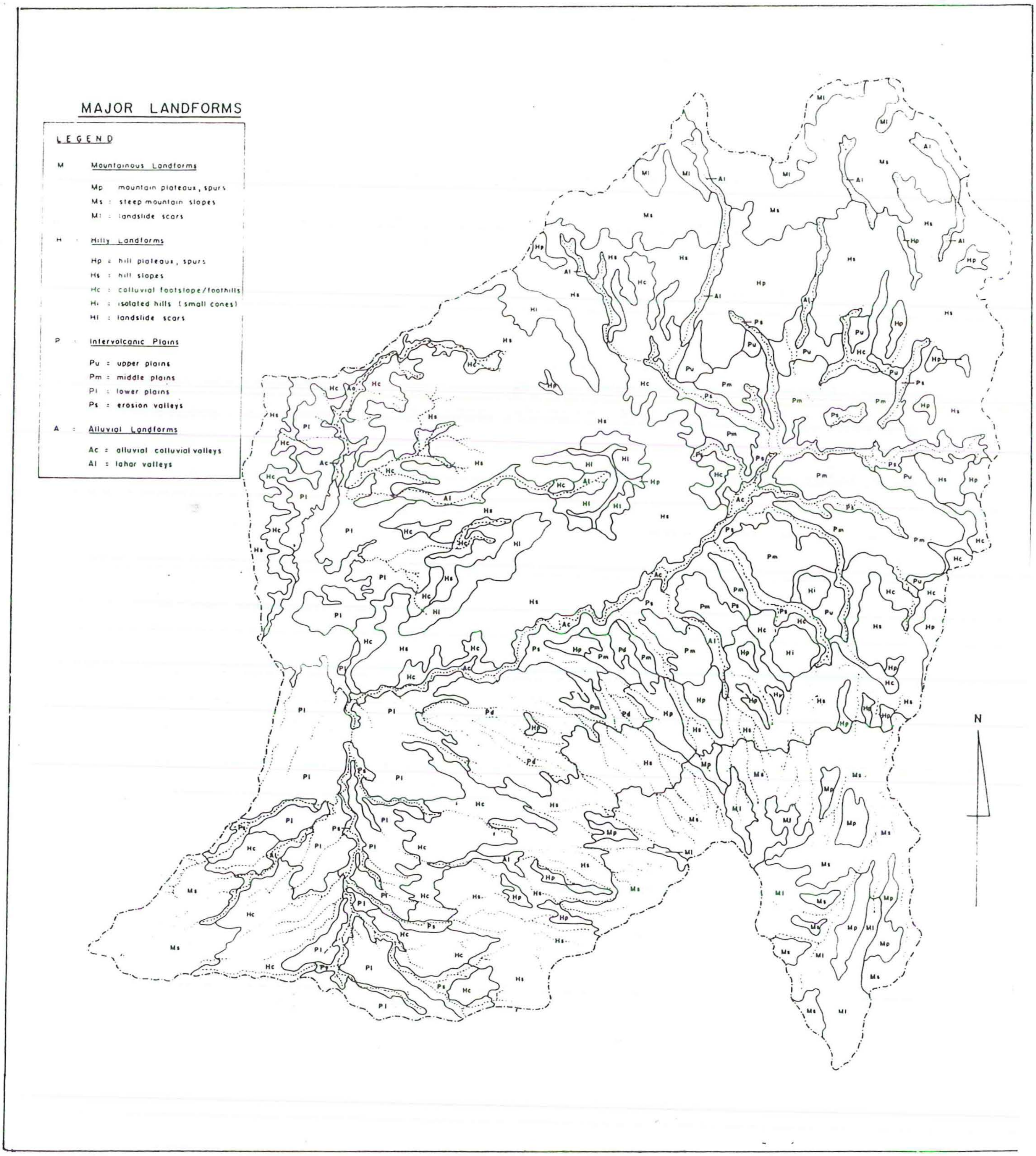


Fig. II.5. Schematic Landform sketch map Kali Konto Watershed (not to scale)

Dry lahar valleys are also included in this landscape. On the 1:50.000 map the following units can be distinguished:

Ac = alluvial and colluvial valleys

The only distinct river course is the U-shaped valley of the Kali Konto. The few other courses are concave colluvial valleys, not well developed, or are modified by man, preparing sawahs and controlling and diverting the water. Other valleys are erosion valleys (units Ps). On the 1:20.000 landform map the irrigated and terraced valleys are separated from the non-irrigated ones. Flooding is very rare as the stream channel is deeply cut in the sediments (Kali Konto), or the river catchments have limited extensions. Soils are often stony and bouldery cambisols or fluvisols, others are medium texture colluvial soils.

Al = lahar valleys

Lahar valleys are old erosion gullies and ravines originating at the steep upper cones of the volcanoes, which later were filled by coarse lahar materials (generally cold or rain lahars). In the process, the deep incised V-gullies changed into U-valleys. They have an irregular surface with stony and bouldery soils, but locally the materials are covered by thin covers of finer textured colluvial sediments. The lahar valleys may extent over long distances, but most do not reach the Kali Konto river system. On the 1:20.000 landform map a distinction has been made between the dry, excessively drained lahar valleys (most common) and the irrigated and terraced valleys. The lahar flow over the sloping plain near Ngantang (the Parangklakah lahar), which actually is not a true valley, has been included in this unit as well.

Intervolcanic plains and plateaux

In the project area there are two major intervolcanic colluvial plains: the Pudjon plain, a slightly concave and sloping plain, between the G. Kawi and the G.Anjasmoro, and the Ngantang plain between the G. Kelud, the G. Kawi and the Anjasmoro range. The Pudjon plain is situated at elevations between 950-1225 m, the Ngantang plain between 620-800 meters. The plains are not related and are separated from each other by the lower slopes of the G.Kawi and the foothills of the Anjasmoro range, with the narrow, deeply incised gorge of the Kali Konto river in between.

On the Pudjon plain two planation levels can be observed: one between 1150-1225 m (the upper plain) and one between 950-1175 m (the middle plain). The Kali Konto river system cut up the plain into several smaller isolated plateaux and the erosion process is advancing headwards. Smaller erosion valleys are found on the Ngantang plain. The following units have been recognized:

Pu = upper plains and plateaux (Pudjon)

Situated between 1150-1225 m, this unit covers only limited surfaces as colluviation from the adjacent foothills have covered this unit in several areas. The plains are (gently) sloping and many are eroded. Soils are well drained andic cambisols and most lands are in use as tegallans; the soils are somewhat drought sensitive and erosion (rill) is locally a problem.

Pm = middle plains and plateaux (Pudjon)

The middle plain covers most of the agricultural areas of Pudjon. The plain is situated between 950-1175 m. a.s.l.and is cut up by the Kali Konto and its tributaries into several individual plateaux; most plateaux are gently sloping (3-8%). On the 1:20.000 landform map the units are subdivided into (i) non-eroded, non-irrigated plains/plateaux (tegallans) with loamy to clayey cambisols, (ii) non-eroded, irrigated plains/plateaux with clayey padisols, mostly in use for intensive horticultural based cropping systems and (iii) eroded plains, sloping (8-20%) and generally irrigated and strongly terraced. On the latter subunit erosion is common, as well as the collapse of sawahs, resulting in "catstep-slopes".

Pl = lower plains (Ngantang)

The lower plains cover most of the Ngantang agricultural lands. Situated between 620-800 m. a.s.l., the slopes are generally gentle (3-8%), but near the small river systems, natural erosion resulted in sloping lands (8-15%). The soils are basically of coluvio-aeolian (volcanic) origin, fine to medium-coarse textured with volcanic sand and pumice particles. On the 1:20.000 landform map, the following subunits are recognized: (i) non-eroded, non-irrigated plains with cambisols and mediteran soils in use as tegallans or as mixed coffee gardens, (ii) non-eroded, irrigated plains with clayey padisols, used for wetland rice based cropping systems and (iii) eroded, irrigated 8-15% sloping plains, generally strongly terraced and in use as irrigated rice land as well.

Pd = dissected (serrated) plateaux

Situated between the upper plains of Pudjon and the lower plains of Ngantang, the unit concerns a sloping dissected plateau, developed in uniform ash. The plateau is traversed by a series of parallel, uniform and ravine type of V-valleys, with the valley sides intersecting in sharp-edged parallel ridges. The valleys have 2-300 meter long, single, straight and steep slopes (20-50%). Soils are andic cambisols, well to somewhat excessively drained. Most of the dissected plateau lands are within the forest boundary and covered by kirinyu vegetation or plantation forest; erosion hazards are moderate.

Ps = erosion valleys

The unit comprises the erosion valleys which deeply cut into the intervolcanic plains.
In the Pudjon area, the valleys cover extensive areas and have steep and very steep valley sides, with 200-400 m long, straight, single, 25-75% slopes. The soils are developed in mixtures of ash and colluvial materials and many are excessively drained. Many valleys and gullies are advancing headwards. Most units are official forest lands and covered with kirinyu vegetation. Erosion susceptibility is high.
In the Ngantang area, the valleys are smaller and more of the U-type, with 15-40% single, straight, rather short (100-200 m) valley side slopes. Soils are slightly gravelly and generally somewhat excessively drained. Erosion hazards are moderate.

Hilly landforms

The largest portion of the watershed is occupied by hilly landforms (approx. 50%). They are found between the intervolcanic plains and mountainous areas. The hills stand out approximately between 200 and 500 meter above the intervolcanic plains with the upper limit at approximately 1400 m.a.s.l.
Many hill zones are denudational, but also colluvial foothills, footslopes and small, single volcanic cones are included. Many hill areas are under natural or plantation forest or kirinyu scrub vegetation, while the less sloping lands are generally in use as tegallan land.
A number of landform units have been recognized:

Hp = hill plateaux and spurs

The unit comprises small, isolated hill plateaux, situated on crests and sloping hill spurs.
Gently sloping (convex, 5-8%) plateaux and moderately steep (12-35%) convex/concave hill spurs. Soils are mostly deep non-eroded andosols.

Hs = hillslopes

This is the largest landform unit. Weathering, denudation and erosion, mainly by sheetwash, is smoothening the land. The unit includes small crests, spurs and colluvial footslopes. On the 1:20.000 landform map a number of subunits are recognized based on differences in relief, erosion and landuse. The slopes, single or complex, are usually convex in the upper slope section and straight or concave in the middle and lower sections. On the higher convex parts most soils are andosols, on the middle and lower parts andic cambisols. The soils are deep to very deep,well drained, locally somewhat excessively or excessively drained. Soil erosion varies;in some areas the hillslopes are not eroded, on other erosion can be moderate or severe, depending on slope characteristics and landuse.

Hc = colluvial footslopes and foothills

This unit concerns colluvial footslopes and foothills and a number of colluvial valleys, the latter particularly in the Ngantang area. The footslope areas generally have 5-15% concave slopes, the foothills are undulating to rolling (5-15% slopes). Most soils are developed in loamy and clayey colluvial materials and are luvisols, phaeozems and cambisols, depending on local conditions and the setting. Most colluvial footslopes are used for irrigated agriculture, upland crops (tegallans) and mixed coffee gardens; the foothills are sometimes found under kirinyu scrub or forest. the colluvial footslopes of the Kelud form a separate unit; the area is dissected and soils are gravelly, pumice-rich soils, excessively drained and marginally suited for agriculture.

Hi = isolated small volcanic cones

Two separate small volcanic cones occur in the area; they stand out some 60 m (G.Amping[2]) and 300 meter (G.Kelet) above the surrounding plains and are characterized by their very steep slopes (30-75%) and smooth surface. The small G.Amping[2] is a spatter cone with cambisols, strongly terraced and in use as tegallan land. The higher G.Kelet is a single eruption cone and has an andesitic rock core; soils are shallow, stony and bouldery andosols (higher parts) and cambisols (lower parts). Most of the Kelet is covered by natural and plantation forest.

Hl = landslide scars and slip surfaces

This unit concerns a miscellaneous landtype of landslip and landslide surfaces, consisting mostly of masses of soil material, weathered rock, stones and other unconsolidated materials that slid down. "No-soil" areas with a pioneer vegetation.

Mountainous landforms

The steep middle and upper slopes of the Gunung Kawi and Gunung Kelud, as well as the highest peaks of the Anjasmoro range are mountainous landforms. In practice it means that all land above 1400-1500 meter, or approx. 20% of the watershed, is mountainous. Most lands are strongly dissected with deep V-shaped ravines. Several landform units can be recognized: crests, spurs, plateaux, steep mountain slopes and landslide scars.

Mp = mountain plateaux, spurs and crests

Although in fact three different units, they have been grouped together. The plateaux concern the least dissected parts of the saddle between the twin volcanoes G.Butak and G.Kawi; spurs are generally found on the upper and middle slopes and the crests are the rims of the watershed and the sharp edged ridges between the ravines. Erosion on these units is limited and all soils are very deep and original andosols, with topsoils high in accumulated organic matter. The units are under natural vegetation.

Ms = steep mountain slopes

Most mountain slopes are steep to extremely steep (50 - 100% slopes and over). Slopes are generally straight, single or complex. Actual erosion varies from slight to moderate (creep, slip and an occasional earthflow) and most soils are developed in thin covers of volcanic ash over weathered andesitic rock and mixed with some creepwash from above.
On the 1:20.000 landform map several subunits have been recognized, based on differences in slope gradient (steep, very steep and extremely steep), degree of dissectation and erosion intensity. There is a precarious balance between vegetation and soils and removal or change in the former may easily result in a collapse and the formation of landslide surfaces (see below).

Ml = landslide scars

A miscellaneous landtype of unstable landslide surfaces, consisting of masses of volcanic ash, soil, debris, weathered rock and other unconsolidated materials that slide down in a constant process. The vegetation on these areas is mostly of a pioneer type.

II.5. GENERAL SOIL CONDITIONS

The major soil groups

This chapter concerns a general description of the soils and soil conditions of the Kali Konto watershed. The chapter is intended as a background paper and an introduction. It is at the same time a description of the generalized 1:50.000 soil map (fig.II.6 and coloured map 2B).

All soils of the area are developed in volcanic materials. Many are developed in windblown fine textured volcanic ash, in re-deposited ash or in coarse ash and pumice gravels, the latter particularly on the slopes of the Gunung Kelud. On very steep surfaces where (natural) erosion is intensive, the ash cover is often thin and soils may be developed partly in weathering products of underlying tuff or andesitic rocks. In the valleys, most soils are developed in mixtures of redeposited volcanic ash and stony and bouldery lahar materials.

Soils generally develop from the surface downwards through weathering, transformation, leaching and illuviation. However, in volcanic areas they also tend to be accumulative and with the addition of fresh ash they tend to develop upwards as well. Over time, the repeated falls of fresh ash can be considerable and many soils of the area have two or more buried older soils within their profiles. The process of ash accumulation has a marked effect on the properties of the soils, since the surface soil is constantly being rejuvenated.

Differences in landforms and climatic conditions resulted in the presence of three geographic soil zones, each zone with a specific pattern of soils. The zones coincide more or less with the three major landscapes as discussed in previous paragraphs:

Fig. II.6. Soil sketch map Kali Konto Watershed

(not to scale)

LEGEND

Soils of Alluvial and Lahar Valleys

KP :	Konto-Pait Association	bouldery Eutric and Dystric Cambisols
ST :	Sereng-Tlogo Association	stony / bouldery Mollic Andosols, Eutric Cambisols and Eutric Alluvial soils

Soils of Erosion Valleys, Plateaux Sides and Dissected Plateaux

BP :	Bendosari - Pinjal Association	Eutric and Dystric Cambisols
BL :	Bendosari - Kraantie Lek Association	Eutric, Dystric and Andic Cambisols

Soils of the Intervolcanic Plains

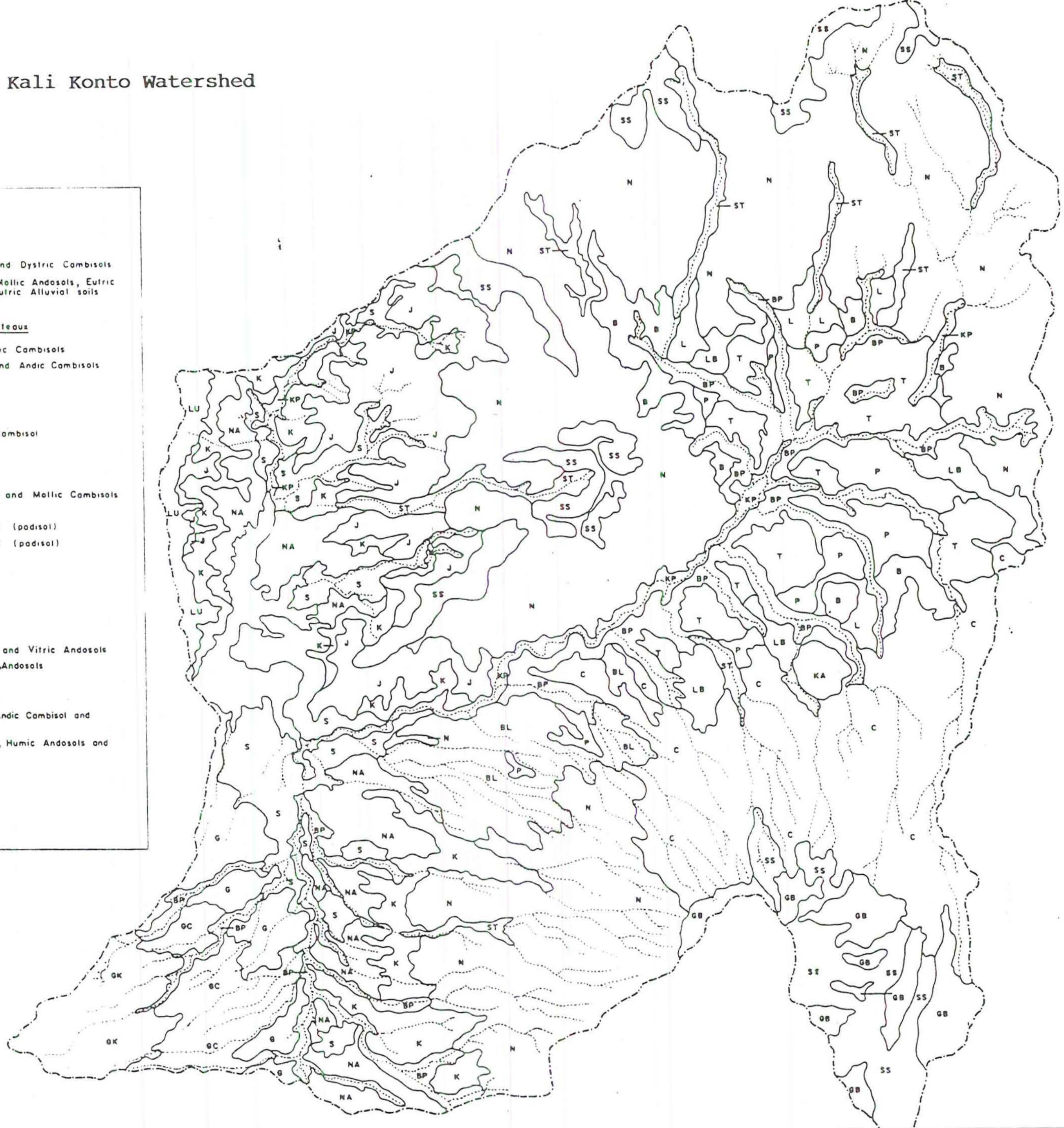
G	Ngantru series	gravelly Andic Cambisol
L	Kraantje Lek series	Andic Cambisol
LB :	Kraantje Lek - Sebaluh Association	Andic Cambisols
NA :	Ngantang - Jabon Association	Mollic Mediteran and Mollic Cambisols
P :	Pujon series	Eutric Cambisol
S :	Selorejo series	Mollic Mediteran (podisol)
T :	Tawangsari series	Mollic Mediteran (podisol)

Soils of the Hills and Mountains

B :	Sebalu series	Andic Cambisol
C :	Coban Rondo series	Humic Andosol
GB :	Gunung Butak series	Humic Andosol
GC :	Gombong Complex	gravelly Mollic and Vitric Andosols
GK :	Gunung Kelud Complex	gravelly Vitric Andosols
J :	Jombok series	Andic Cambisol
K :	Koumrejo series	Andic Cambisol
KA :	Kelet Association	bouldery / stony Andic Cambisol and Humic Andosol
LU	Luksongo Association	Andic Cambisol, Humic Andosols and Lithosols
N :	Ngebrong series	Mollic Andosol

Miscellaneous Landtypes

SS :	Slip and Landslide surfaces	



mountainous landforms	- andosols
hilly landforms	- andosols and cambisols
intervolcanic plains and alluvial valleys	- cambisols and mediterans

(In this paragraph the Indonesian soil classification system of 1981 is used).

The characteristics and properties of the major soil groups will be discussed below .

Andosols[1)]

Andosols are found in the highest parts of the watershed, from the summit of the major volcanic complexes down to approximately 1300 meters, and in some areas even somewhat lower. In the survey area, Andosols cover 51% of the total area.
Andosol is a name connotative of soils formed in volcanic ash, having commonly dark, organic matter rich horizons ("An" = dark coloured, "Do" = soil, in Japanese). Andosols are characterized by a number of particular properties, most of them related to the presence of "allophane", a gellike, amorphous clay mineral which is formed as one of the first weathering products of volcanic ash.

Physically, Andosols have excellent properties including a high porosity, high permeability and a high capacity to retain large amounts of soil water. A very striking property is the very low bulk density, giving the soils a light, fluffy appearance, easy to recognize in the field.

Physico-chemically, Andosols have high exchange capacities and a tendency to fix large amounts of phosphorus. Their fertility levels depend, among others, on the mineralogical properties of

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1) Indonesian and FAO/UNESCO systems.

the volcanic ash in which they are formed. Some andosols have high base saturation values and are well provided with plant-available cationic nutrients, others are leached and low in nutrients or are formed in volcanic ash high in silica and lower in Ca, Mg or K bearing minerals. The buffering capacity of Andosols is high and even the poor and leached ones do not have low pH values.

In the survey area the following Andosol soil units have been recognized:

- Coban Rondo series : loamy; base saturation moderately low in the topsoil and low in the subsoil; pH 5.5-6.0 (Humic Andosol; on the northern slopes of the G.Kawi).
- Ngebrong series: loamy; base saturation high throughout; pH 6.0-7.0 (Mollic Andosol; on the Anjasmoro mountain range and the western slopes of the G.Kawi).
- Gunung Butak series: loamy with a 4-10 cm thick organic top-layer; base saturation low; pH 5.5-6.5 (Humic Andosol; on the upper slopes of the G.Kawi; above approx. 1900 m).
- Gombong complex: sandy ("ashy") and gravelly (pumice); base saturation moderately high, pH 6.0-6.5 (Mollic and Vitric Andosols; on the middle slopes of G. Kelud).
- Gunung Kelud complex: sandy ("ashy") and very gravelly (pumice); high base saturation; pH 6.0-7.0 (Vitric Andosols; on the upper slopes of G.Kelud).

<u>Cambisols</u>[1)]

Cambisols are found on the lower slopes, the foothills and foot-slopes of the volcanic complexes, generally below 1300-1400 meters. They are also found on some parts of the intervolcanic plains. The Cambisols cover approximately 17.5% of the watershed and, after the Andosols, they are the second largest group.

All cambisols in the area are developed in volcanic ash. The evolution from Andosol to Cambisol (Cambic is from "cambiare"= change) concerns particularly a process of transformation of clay

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1) Indonesian and FAO/UNESCO systems.

minerals. In humid tropical areas with alternating wet and dry seasons, allophane is dehydrated rapidly and transformed first into halloysite and later into other crystalline minerals. The transformation causes a gradual loss of the typical Andosol properties. Although still "volcanic ash soils", they often have either/ or higher bulk densities (less "fluffy" character), fix smaller amounts of phosphorus, have more clay, or accumulate less organic matter in the topsoil (also because of the higher temperatures). Clay illuviation is another process taking place. These soils form a particular group, often difficult to classify and relatively little known what their management requirements are concerned.

In the survey area the Cambisols can be grouped into the following soils units:

<u>Andic Cambisols</u>.

Soils still resembling Andosols, but they lost some of the characteristic andosol properties, sometimes even difficult to detect in the field. They are found mostly on the hilly landforms just below 1200-1400 meter. The following series have been recognized:

- Kraantje Lek series: loamy, no clay illuviation; base saturation moderately low; pH 6.0; soils resemble the Coban Rondo soils and are found on the northern slopes of the G.Kawi.
- Jombok series: loamy, no clay illuviation; high base saturation; pH 6.0-6.5; soils resemble the Ngebrong soils and are found on the western slopes of the Anjasmoro.
- Sebaluh series: loam to clay loam with some clay illuviation; moderate base saturation; pH 5.3-6.0, locally higher in the subsoil; typical of the northern footslopes and foothills of the Kawi.
- Kaumredjo series: sandy clay loam - clay loam with some clay illuviation; high base saturation; pH 6.0-7.0; typical of the footslopes and foothills of the Kawi-west and Ngantang.
- Ngantru series: coarse sandy loam with some fine pumice gravels; base saturation is high; pH 6.0-6.5; typical of the footslopes of the G. Kelud.

Andic Cambisols also occur in association with Andosols :

- Kelet association: bouldery and stony Andic Cambisols and Humic Andosols on the Gunung Kelet.
- Luksongo association: Andic Cambisols, Humic Andosols and some Lithosols on the upper slopes of the Luksongo hills.

Mollic, Eutric and Dystric Cambisols.

Although most of these Cambisols are developed in materials derived from volcanic ash, they are more developed and do not belong any longer to the "andic" subgroup. They are typically found on the intervolcanic plains, but also many soils of the alluvial valleys belong to these groups. The following soil units have been established, of which some are associations with other soils.

- Pudjon series: loamy, clay illuviation resulting in an incipient textural-B horizon; base saturation is high; pH 5.8-6.5; typical of the dryland intervolcanic Pudjon plain (Eutric Cambisol).
- Jabon series: sandy clay loam, some clay illuviation; base saturation is high; pH 6.0-7.0 found in association with the Ngantang series on the dryland intervolcanic plains around Ngantang (Mollic Cambisol).
- Bendosari-Pinjal association: soils of the steep erosion valley sides of the Kali Konto and Kali Pinjal river systems; soils developed in mixtures of ash and weathered tuff; soils are eroded, low in organic matter and are droughty; base saturation varies from moderate to high (Eutric and Dystric Cambisols).
- Konto-Pait association: bouldery and stony soils of the alluvial valleys; loamy soils with variable properties depending on the local conditions of sedimentation and drainage (bouldery Eutric and Dystric Cambisols).
- Sereng-Tlogo association: association of loamy soils with variable properties in small colluvial valleys (Eutric Cambisols, some alluvial soils) and stony and bouldery Mollic Andosols in dry lahar valleys.

Mediteran[1] and Padisoils

Increased clay formation and clay illuviation over time lead to

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1) Indonesian system, 1981.

to soils which are clayey and have an argillic horizon, i.e. a subsurface horizon considerable higher in clay than the topsoil and often with a rather dense prismatic structure. The weathering of the volcanic materials (the nutrient reservoir) releases large amounts of cationic nutrients resulting in highly productive soils. Many mediteran soils in the survey area are being used for wetland rice cultivation and could also be named Padisols.

The following soils series have been recognized:

- Ngantang series: clay loam topsoils and well developed clayey argillic horizons; high base saturation; pH above 6.0; found in association with the Jabon series on the dryland intervolcanic plains of Ngantang (Mollic Mediteran).
- Selorejo series: padisol; sandy clay loam topsoil and dense, puddled, clayey subsoils; imperfectly drained; base saturation is high; pH 5.8-6.5; typical padisoil of the Ngantang plain.
- Tawangsari series: padisol; clay loam to clayey topsoil and dense, puddles, clayey subsoils; imperfectly drained; base saturation moderate to high; pH 5.0-6.5; typical padi soil of the Pudjon plain.

Soil Toposequences

Individual soils of the major soil group described above form toposequences, or a succession of soils of increasing maturity from a mountain crest to a valley bottom. They are comparable as they belong basically to one and the same continuum, developed in the same type of parent material (or derived from similar parent materials) and with properties which are changing only gradually.

This gradual process is well demonstrated in fig. II.7. which shows the relation between altitude and some selected physico-chemical properties of the soils of a toposequence on the Gunung Kawi. The decrease in temperature towards the summit of the mountain is in good relation with the increase of organic matter; the decrease in base saturation is explained by increased rainfall and leaching and the higher P-retention values and lower bulk densities are in good relation with the increased allophanic character of the soils.

In fig. II.8, a, b and c, some representative toposequences of soils in the project area are indicated in cross sections.

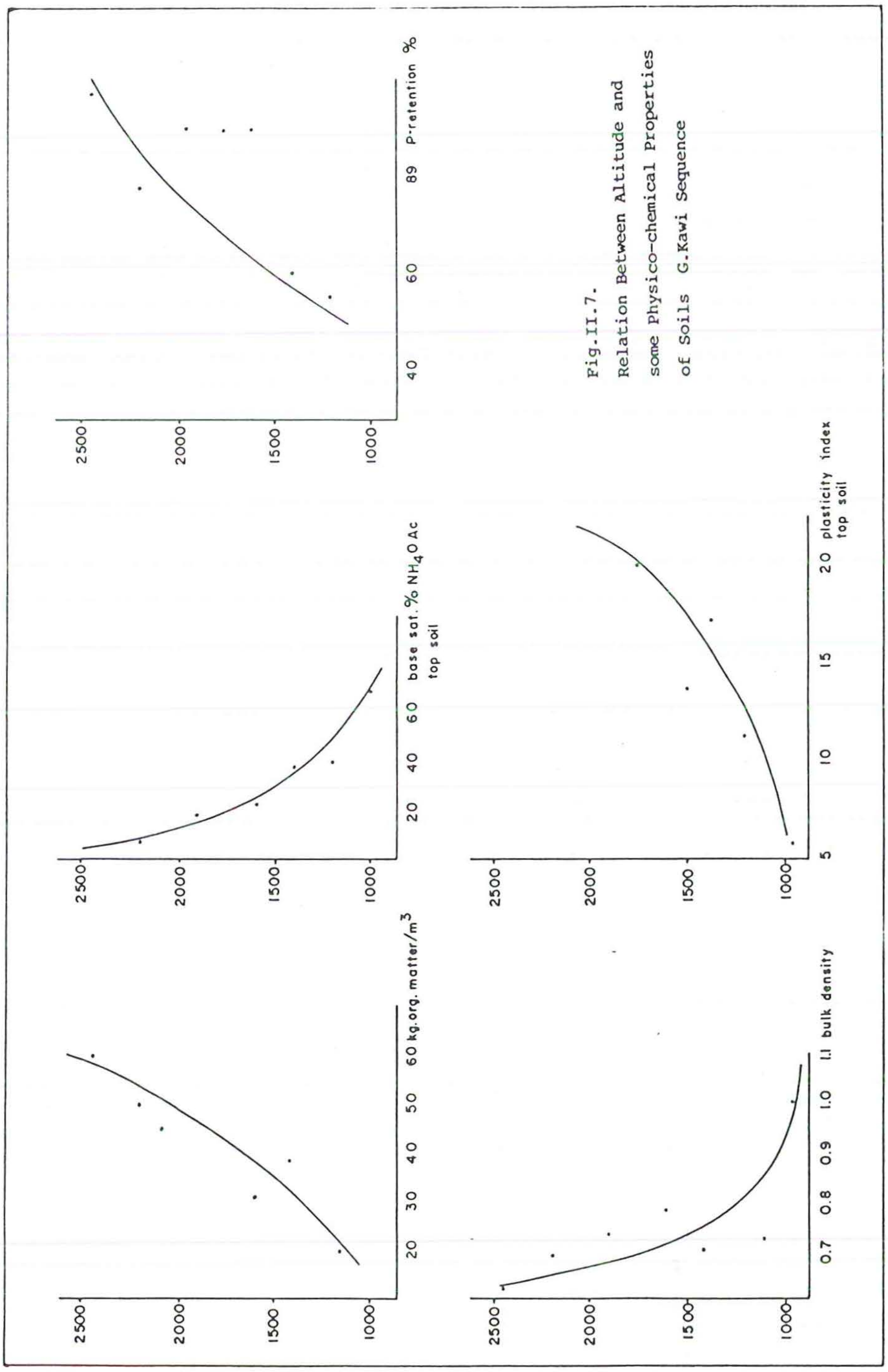

Fig.II.7.
Relation Between Altitude and
some Physico-chemical Properties
of Soils G.Kawi Sequence

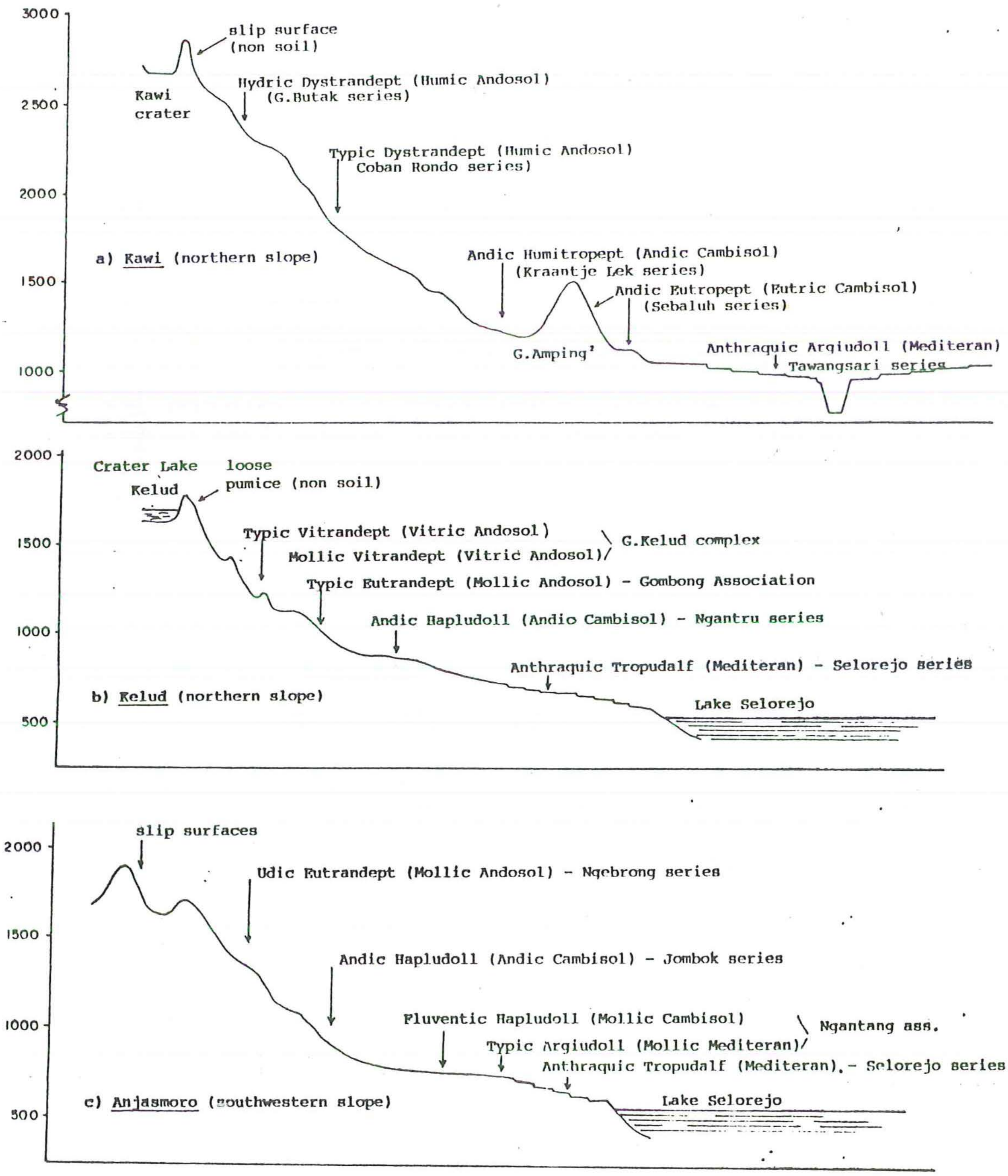

Fig. II.8. Schematic topographical sequences of soils in the Kali Konto Upper Watershed (not to scale)

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SECTION III THE SOIL SURVEY

III.1 INTRODUCTION

Sections III and IV of this report present the results of the soil survey of the Kali Konto Watershed.
In this section (III), the soil survey procedures are discussed first. This is followed by a description of the soil map and a description of the map legend, its composition and structure. The descriptions of the soils of the individual mapping units are found in section IV.

III.2 SOIL SURVEY PROCEDURES

The soil survey of the Kali Konto Watershed is an example of a physiographic soil survey, based on the use and interpretation of aerial photographs.
Soils do not occur in isolation but are organized within the landscape as discrete natural bodies. Recognition of such bodies leads to the concept of three-dimensional soil-landscape systems, which constitute the basis of the physiographic approach of soil mapping. The map boundaries separate different natural soil bodies, which in fact, are sequences or transects of soils in recurrent segments of the landscape.

The area is covered by 1:20.000, 6 inch aerial photography of July 1979 (Aerial Survey Mission Gunung Butak, flown by PENAS). The original "unscaled" 1:20.000 photographs were used for systematic photointerpretation and the 1:20.000 orthophotomaps with contour lines as a base for the final soil map. The transfer of the boundaries from the original photographs to the orthophotomap was a free-hand transfer.
The specific use of aerial photographs in soil surveys concerns interpretation. Soil profiles are not seen on aerial photos and in many areas the thick vegetation prevents the observer from seeing even the soil surface. Photointerpretation for soil surveys, however, works by correlation of general,specific or local nature and includes recognition and identification, analysis and deduction of "elements". In a physiographic soil survey landform and relief are the principal photointerpretation elements and boundaries are drawn on the external properties and characteristics of the landforms as perceived on the photography. In the Kali Konto watershed, the spatial relations between landform and soils are generally clear, in spite of the fact that most soils are formed in the same parent material (volcanic ash) which, being an aeolian sediment, bears no relation with the landform.

The photointerpretation legend constructed for the Kali Konto watershed is composed of four landscapes: the alluvial, colluvial and lahar valleys, the intervolcanic plains, the foothills and the mountain complexes. Each landscape is subdivided into a number of landforms, whose recognition is based on the general relief type and geomorphological processes acting in the past and at present. Up to this level of detail, the units are of general use. Below this level other characteristics are employed such as slope gradient, degree of erosion and agricultural practices of terracing (cut and fill practices) and irrigation for wetland rice cultivation (puddling of soil profiles). These characteristics are particularly important for the soil survey.

Fieldwork in a physiographic soil survey is primarily intended to identify and describe the soils of the physiographic photointerpretation units. However, physiographic soil mapping not only supposes a close relation between soil units and landforms, but also requires that this relation is constant throughout the area. In the Kali Konto watershed this is actually not always the case. The presence of several volcanic complexes in the area, each with a particular history and regime, ejecting different types of materials (fine ash, coarse ash and pumice; all with a variable mineralogy) resulted in different soils on similar landforms.

The soil mapping procedure followed could therefore not be pure physiographic, but, instead, had to be a combination of a physiographic and a "free" soil survey. "Free survey" is Steur's (1961) term for mapping of soils by their boundaries. Once the physiographic and photointerpretation legend is established, the surveyor has to locate some soil boundaries in the field and has to follow them around on their relations with the physiography. Other boundaries are the result of important differences in soil properties determined in the field and/or in the laboratory.

Fieldwork was carried out by two survey teams from November 1982 to July 1983, interrupted from January to March due to heavy rains. The work was concentrated first in pre-selected sample areas, strips, transects and toposequences (catena's). One of the sample areas was the subwatershed Kali Sereng (600 ha), surveyed already earlier. After final photointerpretation and soil correlation, field work continued outside the sample areas (extrapolation survey), particularly in those areas not well covered by the sample areas and in dubious spots.

All fieldwork included :

- identification and description of the soils of the different photointerpretation units
- checking of the boundaries drawn by aerial photointerpretation
- soil correlation, followed by modification or deletion of some boundaries, creation of new boundaries based on significant soil differences found in the field and/or the laboratory. The relations between physiography, photo-image and soil conditions being clear in most areas, the corrections were minor.

Field work included the description of 950 soil observations made by spade to a depth of 40-50 cm and further by auger to a depth of 120 cm.
An additional 300 less detailed observations (confirmations) were made along roadcuts, gully banks, terrace benches or just by auger only. Soil descriptions were made following the Soil Survey Manual and the FAO Guidelines for Soil Descriptions, adapted somewhat to local conditions. The format of the field observation sheet is shown in the Annex.

A total of 51 representative soil profiles were studied and sampled. In addition compound topsoil samples were collected from about 60 different and representative farmer's fields. The laboratory analysed a total number of 393 soil samples. Determinations included standard routine determinations and special analysis to characterize the particular properties of soils developed in recent volcanic ash. The analytical laboratory methods are described in the Annex as well.

The sequence of activities carried out is summarized as follows:

step 1. The collection and study of available documents and data concerning the area, including base maps and geologic, climatic and soils data in report and map form.

step 2. Survey of the Kali Sereng subwatershed (600 ha). (November/December 1981). Survey report submitted in April 1982.

step 3. A preliminary field reconnaissance study and selection of additional sample areas, transects and catena's (November 1982).

step 4. Field survey of the sample areas (November 1982 - April 1983) and systematic aerial photointerpretation during periods of heavy rains.
Final version 1:20.000 landform map and descriptive legend (incl. landform, soils and erosion) submitted in July 1983.

step 5. Preparation of preliminary soil legends, followed by a field extrapolation survey (March-April 1983) and the preparation of a preliminary soil map.

step 6. Selection and detailed description, study and sampling of representative soil profiles (May-June 1983).

step 7. Laboratory analysis; followed by soil classification and preparation final soil legend (May-November 1983).

step 8. Final soil correlation in the field, preparation of the final soil map (December 1983 - January 1984); final soil map submitted in March 1984.

step 9. Land Evaluation (October 1983 - March 1984).

step 10. Preparation of the soil survey report (March - June 1984) and a set of generalized maps.

III.3. THE SOIL MAP

The physiographic soil map of the Kali Konto watershed is presented at a scale 1: 25.000.

The map is printed on a grey-tone orthophotomosaic, prepared by the International Training Centre for Aerial Survey (ITC) in Enschede, the Netherlands.

The use of a photomap as a basemap has the advantage that each individual field or tract of land can easily be located on the map. Coloured maps have the advantage of a better general view of the soil conditions of an area and may show better, through different colours, the spatial relationships between the various soil units. To serve the purpose of regional watershed and landuse planning, a set of generalized soils, landform and soil erosion maps have been prepared as well. The scale of these maps is 1: 50.000. The maps have been printed by the Research Institute for Nature Management, Leersum, the Netherlands.

Additional easy reproducible black and white diazoprint copies of all maps prepared are available from the Soil Science Department of Universitas Brawijaya in Malang. Copies of the original transparancies can be made available as well.

Although the basemap essentially is an orthomap, the vertical distortion in the steep higher parts of the mountains is often considerable and for these areas the maps are not exact. For these areas the maps are actually sketchmaps and should be used as such.

All soils of the area are formed in volcanic materials. But because of striking differences in the properties of these materials, differences in altitude, landform, drainage conditions, climatic factors and landuse within the are, the soil patterns are intricate. The pattern of the slopes of the Kawi is very different from that of the Kelud, while on the slopes of the Anjasmoro range the pattern is different again.

The intricated soil pattern resulted in the initial recognition of over 75 different mapping units, a number too large to cope with one's mind. Therefore, in the final soil correlation, instead of being over-intent on drawing attention to differences, similarities between soils were stressed. As a result, a total of 56 different mapping units were retained and recognized on the final 1:25.000 soil map. The number of different mapping units on the generalized soil map is 22.

III.4. THE LEGEND

The legend of the soil map is presented as a separate appendix. In the legend, the mapping units are arranged physiographically, the soils being classified according to the landform to which they are associated. The arrangement reveals the complex relation between landform and soils in the area.

The tabular explanatory legend consists of four columns. In the first column the mapping symbols are indicated as they appear on the soil map. The symbols are in the form of a fraction. The numerator refers to the landform unit. The denominator refers to the soil unit(s) within the landform unit.
The second column gives the full names of the soil unit(s) of each landform unit. Many soil units are soil series, many others associations of series or soil complexes.
The third column indicates the slope gradient and slope type, as well as the degree and type of present erosion.
In the fourth column, the classification of the soils are indicated according to the US Soil Taxonomy Soil Classification System. Details of each aspect are outlined below.

Landforms

The soil map being a physiographic soil map, the landform is the first entry in the mapping symbol. It is indicated in the numerator of the mapping symbol with a special code. The various landforms are described physiographically, rather than strict geomorphologically. The landforms, together with their soil units, are arranged in the legend approximately from low (alluvial landforms) to high (volcanic mountainous landforms).
The codes used for the landforms are as follows:

Table III.1.

Key to landforms (sequence as in the legend)

A	**Alluvial and lahar valleys**
Au	U-shaped valleys
Ac	colluvial valleys with concave valleyfloors
Al	recent and subrecent lahar valleys
P	**Intervolcanic Plains and Plateaux**
Pu	upperplains and plateaux; 1150-1225 m. a.s.l.
Pm	middle plains and plateaux; 950-1175 m. a.s.l.
Pl	lower plains and plateaux; 620-800 m. a.s.l.
Ps	steep plateaux sides along plateaux margins
Pe	plateaux scarps along plateaux margins
Pd	dissected (serrated) plateaux with parallel steep ridges
Pv	small erosion valleys
H	**Hilly Landforms**
Hc	colluvial foothills and footslopes
Hi	isolated small volcanic cones (single eruption cones)
Hp	small hill plateaux, crests and spurs
Hs	hill slopes
M	**Volcanic Mountainous Landforms**
Ms	mountain slopes of the G.Kawi and Anjasmoro
Mk	mountain slopes of the G. Kelud
Mc	colluvial footslopes and debris slopes
Mu	mountain spurs and crests

Soil units

The denominator of the mapping symbol refers to the soil unit. The soil unit is indicated with a code and the full name is given in the second column of the explanatory legend.

Many of the soil units are soil series (e.g. Selorejo series), others are soil associations (e.g. Ngantang association) or soil complexes (e.g. Kali Pait complex).

The soil series is a grouping of soils with similar modal profiles, properties and characteristics and developed in the same or very similar parent materials. In the area of the Kali Konto watershed, the series is used with a somewhat wider meaning as specified in the Soil Survey Manual (1951). The variation in the parent volcanic materials over short distances and the human influences on the soils (e.g. terracing) made it impractical to follow the strict meaning and to create numerous narrowly defined series. All series are given local geographic names, indicating the localities where the soils of the series are well developed. In some instances the series name refers to the locality where the soil is first described. In the Kali Konto watershed 13 soil series are recognized.

Some mapping units are compound units, having a particular pattern of two or more different soil units. In some of the compound units the individual soils are found in a regular pattern or are geographically associated (soil associations). Nine different soil associations are recognized in the area. In other compound mapping units the individual soils cannot be mapped separately because of their very intricate pattern or indistinct boundaries. These mixtures of soils are called soil complexes. In the Kali Konto watershed seven soil complexes are identified.

Soil phases are subdivisions of soil units (series, associations or complexes) that are potentially significant to landuse or the management of land, but are not diagnostic for the separation of the soil units themselves. Phases are extremely useful to drawing attention to marked differences of practical significance (erosion for example).

Soil phases are indicated by a special code following the soil code in the denominator of the soil mapping symbol. The following soil phases are recognized:

Table III.2.

Soil phase symbols	
e	moderately eroded
E	severely eroded
t	strongly terraced (particularly on hilly landforms)
s	stony, bouldary

Special criteria are used to map the soils of the steep mountain slopes. On these surfaces there is generally a rather intricate yet predictable pattern of soils, often arranged in a simple clino-sequence. Thus on the upperslopes and crests of the complex mountain slopes the soils are generally well developed and deep. On the steep slope sides they are not only eroded, but as a result of the continuous process of erosion (slips, small landslides) and deposition, they are more varied and different. By convention, sequences of this nature are not considered as associations or complexes. In stead, they are named according to the modal soil. The convention, however, does not apply where differences in parent material give rise to soils of more than one clinosequence within the mapping unit. Such units are mapped as ordinary associations or complexes.

Slope characteristics

In the third column of the explanatory legend the slope type (single or complex, concave, convex or straight) and the dominant slope gradients are indicated. The slope classes used are adapted from the Soil Survey Manual and the Soil Survey Institute Bogor, as follows:

Table III.3. Slope classes

A. Single slopes

0,5 %	level	15-30 %	moderately steep
1-3 %	nearly level	30-50 %	steep
3-5 %	very gently sloping	50-100 %	very steep
5-8 %	gently sloping	100 %	extremely steep
8-15 %	sloping		

B. Complex slopes

Classes are established with alternative minimum and maximum limits in terms of gradient

lower limit	0	%	flat to nearly flat
upper limit	1-3		
lower limit	1-3	%	gently undulating
upper limit	3-5		
lower limit	3-5	%	undulating
upper limit	5-8		
lower limit	5-8	%	rolling
upper limit	8-15		
lower limit	12-20	%	hilly
upper limit	20-30		
lower limit	20-30	%	steep hilly
upper limit	30-50		
lower limit	30-50	%	mountainous
upper limit	50 +		

Soil erosion

In considering erosion it is necessary to differentiate between natural erosion, being part of the geomorphic cycle whereby land is being gradually reduced to sealevel and the acceleration of this natural process or soil erosion, due primarily to man's interference within an existing natural ecosystem.

The forms of natural erosion prevalent in the Kali Konto watershed are classified as follows:

creep erosion	: slow mass movement under the influence of gravity
slip erosion	: sliding or slipping of soil and underlying material upon a slipping surface
flow erosion	: the more rapid of the mass movements, including earthflows, mudflows and debris avalanches

The forms of accelerated soil erosion are

sheet erosion	: the more or less uniform removal of top soil material without the development of conspicuous water channels
rill erosion	: the removal of soil with the formation of numerous but definite water channels
gully erosion	: the removal of soil and underlying material by streams of running water with consequent formation of relatively large channels with steep sides

In assessing the degree of erosion, the criteria used in this survey are specific to the soil type. For example, the erosion of shallow soils over rock or over infertile bands of cindery and pumice materials cannot be assessed from the same criteria as are used for the erosion of very deep homogeneous volcanic ash soils suffering much less change in their properties when eroded.

In the Kali Konto watershed the degree of erosion is estimated in the first instance by the proportion of the area affected and this estimate is being weighted against other criteria such as the depth of the fertile topsoil and the properties of the subsoil, which affect the soil's agricultural potential.

The degree of actual erosion is then obtained by combining the proportion of the area affected and the degree of soil degradation and is arranged as follows:

slight erosion : less than 15% of the area is affected; soil degradation is slight and less than 20% measured as the decrease in the land's productivity.

moderate erosion : between 15-40% of the area is affected and/or soil degradation is moderate; the production potential of the land decreased with 20-50%.

severe erosion : over 40% of the area is affected and soil degradation is severe with a decrease in the land's productivity of 50% or more.

As the present stage these classes can only be tentative and cannot be defined more precisely, since the assessment requires observations on soil conditions and crop performance over long periods.

Soil phases based on actual erosion are established only when they are significant to land use.

Soil description

In the last column of the explanatory legend the soil units are described and classified.

The descriptions are very short and only refer to the drainage conditions, soil depth, rockiness and stoniness (if present), the soil texture and information on terracing and irrigation (puddling) practices, if present. This is followed by the classification of the soils in the terms of the US Soil Taxonomy.

The detailed descriptions of the soil units are found in section IV of this report.

The descriptive terminology used in the legend is the standard terminology of the Soil Suvey Manual and the Guidelines for Soil Description. A summary of this terminology is given below:

natural drainage classes :

imperfectly drained : the water is removed from the soil slowly enough to keep it excessively wet for significant periods moderately well drained : the soil is excessively wet during small parts of time

well drained : near optimum amounts of soil moisture are retained for lengthy periods

somewhat excessively drained : moisture deficiency frequently limits plant growth, also during the cropping season

excessively drained : very little water is retained in the soil and most is removed very rapidly (very sandy, shallow soils or on steep surfaces)

soil depth classes :

00-50 cm	: shallow	80-140 cm	: deep
50-80 cm	: moderately deep	over 150 cm	: very deep

soil texture classes :

refers generally to the texture of the subsoil between 25-100 cm and is based on the whole soil, including the coarse fraction:

loamy	: sandy loam, sandy clay loam and clay loam with less than 35% clay and less than 35% gravels, stones, etc.
clayey	: clay, sandy clay, silty clay and clay loam with over 35% clay and less than 35% gravels, stones, etc. (fine clayey has over 60% clay)
medial	: volcanic ash soil that feels loamy (handfeeling)
ashy	: volcanic ash soil that feels sandy (handfeeling)
cindery	: over 60% of the soil is cinders, pumice or coarse ash; 35% or more has a diameter of 2 mm or more
skeletal	: over 35% of the soil is rock, stone, gravel, etc. but there is enough fine soil to fill the space between the rock fragments or stones (hence: loamy-skeletal, clayey-skeletal)

Soil classification

In the explanatory legend the soil units are classified according the US Soil Taxonomy system.

The survey team would have preferred the use of the Indonesian soil classification system. The latter system is based on the principles of the FAO-UNESCO legend for the Soil Map of the World and is only a two-level system: the soil order and unit. Both systems being designed particularly for exploratory and broad reconnaissance soil surveys and maps, they are, in the present form, less suitable for use in detailed surveys for which they lack sufficient detail. A third-level terminology (subunits) needs to be developed to express the greater amount of detail required. As a step in that direction the survey team introduced a number of additional units and subunits in the Indonesian and FAO-UNESCO systems. However, the survey area being small, the attempt could only be tentative and is certainly very incomplete. It is for that reason that the US Soil Taxonomy system has been used as the principal reference system.
A classification correlation table at the back of the legend sheet gives the equivalents in both the Indonesian and FAO-UNESCO systems. In the table the new proposed units and subunits are indicated as well.

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SECTION IV THE SOILS

IV.1. INTRODUCTION

This section describes the soils of the individual mapping units as they appear on the soil map. As explained already earlier in this report, the symbols of the mapping units have the form of a fraction. The denominator of each symbol constitutes the code of the soil unit. In the legend the full name of the soil unit is indicated. This name is the entry for this section.

For example, if we want to be informed about the soils of mapping unit $\frac{Pm}{T}$, we first consult the legend. The legend indicates that T stands for Tawangsari series. We then refer to this section of the report for the required information. The soil units are listed alphabetically.

The soils are described basically in a technical but not a pure scientific language, based on the terminology outlined in the Soil Survey Manual (USDA 1951), Guidelines for Soil Description (FAO, 1967) and the Munsell soil colour notations. A summary of the terminology is given in Section III.

All scientific and technical data which may interest the individual soil scientist, but which may be difficult to understand and interpret by the user of this report in charge of landuse planning, have been omitted. These data are given in the Appendix.

For a more general description of the soil conditions of the Watershed, reference is made to Section II, chapter II.5, as well as to the generalized soil map to a scale 1:50.000.

IV.2. DESCRIPTION OF THE SOIL UNITS

BC BENDOSARI COMPLEX

This unit concerns a complex of well and somewhat excessively drained, deep and loamy soils of the steep erosion valley sides; they are developed in mixtures of redeposited volcanic ash and weathered tuff. Due to erosion, deposition and terracing, the soil properties may vary over rather short distances.

A representative profile is described in the annex.

setting : steep to very steep (25-75%) valley sides; the unit separates the intervolcanic middle plains and plateaux from the valleys of the Kali Konto and its tributaries.

land use : most lands are within the forest boundary and planted with Pinus, Damar or Eucalyptus, but the stands are often damaged or very poor and invaded by scrub; some parts are in use as agroforestry land or are terraced and irrigated.

soils : the soils have a limited water-holding capacity and as run-off and permeability are rapid, many soils dry out quickly. The topsoils are 0-25 cm deep, dark brown to dark yellowish brown in colour, have a loamy texture and a weak and fine granular and subangular blocky structure.
The subsoils are developed in mixtures of ash and weathered tuff and have clay loam to clayey textures and moderate blocky structures. Buried profiles are common.

erosion : varies from slight to severe (rills, creep and slip)

soil fertility : due to erosion, the soils are generally low in organic matter (1-3%). The soil reaction is very slightly acid (pH 5.7-6.5). In spite of the low organic matter levels, the soils are well provided with available cationic nutrients with base saturation values between 40-95%. The soils show marked responses to N and P fertilizers.

competing series : -

classification :
Typic Ustropept, Ustic and Typic Dystropept - Soil Taxonomy
loamy, mixed?, isohyperthermic
Eutric and Dystric Cambisol - LPT and FAO

mapping unit established :
Ps/BC Bendosari Complex on steep and very steep plateau sides (total area: 211 ha)

BL BENDOSARI-KRAANTJE LEK ASSOCIATION

An association of soils developed in base-rich volcanic ash and colluvial materials derived from ash and tuff and found on the dissected (serrated) plateaux with sharp parallel ridges. Approximately 50% of the soils are in the Kraantje Lek series,

the other 50% belong to the Bendosari complex. The former are found on the ridges and upper slopes and the latter on the steep middle and lower slopes. The soils of the very narrow valleys are again Kraantje Lek soils, with thickened topsoils.
For the description see the individual units of the association

mapping unit established:

Pd/BL Bendosari-Kraantje Lek association on serrated plateaux (total area : 651 ha)

BR BENDOSARI-LITHOSOL ASSOCIATION

An association of soils of the Bendosari complex, Lithosols and "non-soils" found on plateau scarps. On the steep and very steep upper parts (50-100% slopes) the soils are of the Bendosari complex, the middle and lower slopes are near vertical escarpments with Lithosols and rockland.

Pe/BR Bendosari-Lithosol association on plateau scarps (total area : 43 ha)

C COBAN RONDO SERIES

The Coban Rondo soils are deep and very deep young volcanic ash soils of the steep hill and mountain slopes. Typically, the Coban Rondo series have well drained, permeable and porous, loamy profiles with near black, humus-rich fluffy topsoils and dark yellowish brown subsoils with low bulk densities. Well developed buried profiles are common. The soils have excellent physical properties but are characterized by rather small amounts of available nutrients.

A typifying profile is described in the annex.

setting ; steep hill slopes and mountain slopes, small hill plateaux, mountain spurs and crests of the Northern slopes of the Gunung Kawi. The soils are found between approx. 1250 and 1900 meter above sealevel.

landuse : natural and degraded mountain forest, kirinyu scrub vegetation and locally agroforestry systems.

topsoils : the soils have 18-40 cm deep black or very dark brown topsoils, very rich in organic matter (10-17%), a loamy to sandy loam texture on handfeeling (pseudosands of clotted ash particles) and a fluffy, light, granular and subangular blocky structure.

subsoils : the subsoils are invariably dark yellowish brown with a clay loam texture on handfeeling and a weak angular blocky structure. The subsoils are very porous and permeable. Below 75-100 cm, most soils have a buried older profile.

erosion : approximately 50% of the area with Coban Rondo soils is not or only slightly eroded (splash erosion); approx. 25% is moderately eroded (rill, some slip erosion), while the remaining 25% is severely eroded (slip and flow erosion).

soil fertility : the Coban Rondo soils are high in organic matter. They are moderately supplied with available cationic nutrients, though many subsoils are magnesium deficient; base saturation is between 20-50% in the topsoils and 10-40% in the subsoils. Although the fixation of added phosphate is high (over 80%), the available P-levels in the topsoils are satisfactorily. The soil reaction is slightly acid in the topsoils (pH 5.5. - 6.0) and somewhat higher in the subsoils (pH 5.7-6.4).

soil phases :
- moderately eroded phase, on steep and very steep hill and mountain slopes
- moderately eroded and strongly terraced phase on steep and very steep hill slopes
- severely eroded phase on very and extremely steep mountain slopes
- strongly terraced phase

competing series : similar soils are in the Ngebrong, Gunung Butak and Kraantje Lek series. Ngebrong soils are base-rich volcanic ash soils and are found on the Anjasmoro and the western slopes of the G. Kawi. Gunung Butak soils have a 5-10 cm thick organic topsoil layer and are situated above 1900 meter on the G.Kawi. The Kraantje Lek series are found below approx. 1250 meter and are slightly more developed.

classification:
Typic Dystrandept, medial isothermic - Soil Taxonomy
Humic or Humic-Melanic Andosol - LPT and FAO/UNESCO

mapping units established :

Hc/Ct	Coban Rondo series, strongly terraced on 8-15% colluvial footslopes (total area : 72 ha)
Hp/C	Coban Rondo series, on small hill plateaux and crests (total area : 291 ha)
Hs/C	Coban Rondo series, on 30-75% hill slopes (total area : 403 ha)
Hs/Cet	Coban Rondo series, moderately eroded and strongly terraced on 30-75% hill slopes (total area : 362 ha)
Hs/Ct	Coban Rondo series, strongly terraced, on 25-60% hillslopes (total area : 66 ha)

Ms / C	Coban Rondo series, on 15-50% slightly dissected mountain slopes	(total area : 274 ha)
Ms / Ce	Coban Rondo series, moderately eroded on 50-125% dissected mountain slopes	(total area : 63 ha)
Ms / CE	Coban Rondo series, severely eroded on strongly dissected mountain slopes over 100%	(total area : 697 ha)
Mu / C	Coban Rondo series, on 40-75% convex mountain spurs	(total area : 69 ha)

GA GOMBONG ASSOCIATION

An association of well and somewhat excessively drained soils developed in stratified, geological recent ash and pumice layers and found on he foothills of the Kelud volcano. Approximately 40% of the soils are developed in ash with only moderate amounts of pumice (Eutrandepts), while the remaining 60% are gravelly or have thick layers of pumice (Vitrandepts). All soils have a buried profile.

A typifying profile of the Vitrandepts is described in the annex.

setting : sloping and moderately steep (12-15%) colluvial and slightly dissected foothills of the Gunung Kelud, between approximately 775 and 900 meters above sealevel.

land use : most lands are within the forest boundary and many are planted with mahoni or pinus; many others are covered with scrub or a degraded natural forest vegetation.

topsoils : the topsoils of the Eutrandepts are 20-40 cm deep, very dark coloured and with a sandy loam "ashy" texture with only few pumice gravels. The Vitrandept topsoils generally do not exceed 25-30 cm and have up to 10% pumice gravels. All topsoils have an abrupt boundary to an underlying 10-30 cm thick pumice layer.

subsoils : the subsoil consists of a buried profile extending from 40-65 cm to 100-120 cm below the soil surface. The amount of pumice in the buried profile varies from up to 5% in the Eutrandepts to approx 25% in the Vitrandepts. Below the buried profile there is another thick layer of pumice.

soil erosion : slight to moderate (rill, splash, slip).

soil fertility : the soil organic matter levels are moderate (3-4% in the topsoil, increasing to 4-6% in the buried profile and decreasing to approx 1% in the deeper subsoil). The soil reaction is slightly acid (pH 6.0-6.5) throughout. Base saturation in the Vitrandepts varies from 35-50% in the topsoils, increasing to 50-70% in the buried profile. In the Eutrandepts, base saturation is over 50% throughout. Some subsoils are deficient in magnesium. The available phosphorus levels are satisfactorily in the topsoils, but the subsoils are very P-deficient with high P-fixing capacities. The pumice layers are virtually sterile.

competing series : similar soils are found in the Ngantru series and the Gunung Kelud Complex. The Ngantru series have much less pumice gravels and are more developed. The subsoils of the Gunung Kelud Complex soils are almost pure gravel (stratified pumice).

classification:

Umbric Vitrandept and Typic Eutrandept medial over cindery, isohyperthermic	- Soil Taxonomy
Melanic-Vitric and Mollic-Vitric Andosol	- LPT
Humic-Vitric and Mollic-Vitric Andosol	- FAO/UNESCO

mapping unit established :

Hc/GA Gombong association on 12-25% sloping and moderate steep foothills of G. Kelud (total area : 161 ha)

GC GOMBONG COMPLEX

The unit concerns a complex of (somewhat) excessively drained, moderately deep and deep soils, developed in stratified layers of recent pumice and ash.

setting : strongly dissected, moderately steep and steep foothills of the Gunung Kelud, between approx 775 and 950 meters above sealevel.

landuse : most lands have a degraded forest and kirinyu scrub vegetation; some Pinus and Mahoni plantations

soils : the soils are similar to the soils of the Gombong association, but due to natural erosion, the different ash and pumice layers are often mixed, leading to a complex of soils with variable amounts of pumice gravels and associated properties which vary over short distances. See Gombong association.

erosion : moderate rill and gully; some slip erosion.

soil fertility : the organic matter levels are lower than in the soils of the Gombong association and do not exceed 3%. Base saturation and other properties are similar.

classification :

Typic and Entic Eutrandepts	- Soil Taxonomy
Umbric and Typic Vitrandepts	
Mollic and Vitric Andosols	- LPT and FAO/UNESCO

mapping unit established :

Hc/GC Gombong Complex, on hilly 15-40% dissected foothills of Gunung Kelud (total area:353 ha)

GB GUNUNG BUTAK SERIES

The Gunung Butak series are deep and very deep, well drained and intensively leached volcanic ash soils found on the steep mountain slopes of Gunung Kawi/Butak above 1900 m. Typically, Gunung Butak soils have a 4-10 cm thick organic toplayer followed by a near black, humus-rich topsoil and dark brown subsoils. The subsoils are slightly thixotropic.

A typifying pedon is described in the annex.

setting : steep to extremely steep mountain slopes, crests and spurs of the Northern upper slopes of the Gunung Butak and Kawi. The soils are found above 1900 m. approximately.

landuse : montane high forest: Casuarina junghuniana (Cemara) and mixed forests; locally degraded into a mixed forest-scrub or scrub vegetation.

topsoils : typically, Gunung Butak soils have a 4-10 cm thick organic litter layer consisting of slightly decomposed organic matter (casuarina needles, tree leaves, herbaceous material). The litter is followed by a 30-50 cm deep black or very dark topsoil, high in organic matter (11-18%), with a sandy loam to loam "ashy" texture on handfeeling (pseudosands) and a light and fluffy, granular and subangular blocky structure. In eroded profiles, the topsoils are less deep and even very shallow; depending on the degree of erosion and mixing of materials their properties may vary.

subsoils : the subsoils are dark brown to dark yellowish brown with a loam to clay loam texture on handfeeling and a moderate to weak angular blocky structure. The subsoils are generally porous, permeable and with a smeary consistence (thixotropism). In eroded soils they are often mixed with materials derived from weathered andesitic rocks and are less porous and permeable, and have more clay.

erosion : approximately 25% of the Gunung Butak soils are not eroded; the remaining part being moderately (15%) or severely eroded (60%). Erosion is natural slip or flow erosion.

soil fertility : the Gunung Butak soils are leached and low in available cationic nutrients, particularly in magnesium. Base saturation varies from 5-25% in the topsoils, decreasing to 5-10% in the subsoils. In subsoils developed in weathered ande - site (eroded profiles) the values are often higher (30-45%). P-retention is particularly strong (over 80%) but available phosphorus (organic) levels are moderate. The soil reaction is slightly to very slightly acid throughout (pH 5.5-6.5). The soils are high in organic matter (11-18%).

soil phases:
moderately eroded phase, on 50-125% dissected mountain slopes
severely eroded phase, on extremely steep (over 100% mountain slopes

competing and associated series : -

classification :

Hydric Dystrandept, medial over thixotropic - Soil Taxonomy
Humic Andosol - LPT and FAO

mapping units established :

Ms/GB Gunung Butak series, on moderately steep and steep (15-50%) mountain slopes (total area : 165 ha)

Ms/GBe Gunung Butak, moderately eroded on very steep (50-125%) mountain slopes (total area : 82 ha)

Ms/GBE Gunung Butak series, severely eroded on extremely steep mountain slopes (total area : 388 ha)

GK GUNUNG KELUD COMPLEX

This units concerns a complex of very deep, excessively drained soils developed in stratified, geologically recent ash and pumice layers and found on the middle slopes of the Kelud volcano.Most soils have a dark coloured base-rich topsoil developed in ash and overlying a shallow buried profile and with a deeper subsoil consisting of thick layers of coarse pumice.

Two representative profiles of the complex are described in the annex.

setting : very steep middle slopes of the Gunung Kelud, between approximately 950 and 1450 meter above sealevel.

land use : all lands are within the forest boundary: degraded montane forest, scrub vegetation and locally a pinus plantation.

topsoils : most topsoils are 8-15 cm deep but due to erosion and mixing, the thickness may vary from only a few centimeters to over 35 cm. They have a sandy loam "ashy" texture with up to 20% pumice gravels and have a fluffy, granular and subangular blocky structure.

subsoils : below the shallow topsoil there is usually a 10-20 cm thick gravelly layer with 5-30% (vol.) pumice gravels, abrupt overlying a buried profile with well developed A horizons and with variable amounts of pumice. Below 60-85 cm from the surface there are thick layers of coarse pumice. In other profiles there is another pumice layer just above the buried profile.

soil erosion : moderate or severe natural erosion (rill and gullies leading to dissectation of the landform).

soil fertility : the organic matter levels increase with increasing altitude from approximately 5% at 950 m to approx. 10% at 1400 m. The soils are very slightly acid to neutral (pH 6.0-7.0).

Base saturation is high and varies from 70-90%. The topsoils are well provided with plant available phosphorus and the P-retention capacities of the surface layers are surprisingly low (20-30%). The subsoils, however, are low in phosphorus and have P-retention values of 50-70%. Most soils are deficient in potassium, partly due to Mg/K imbalances; there is however no constant trend. The pumice gravel layers are virtually sterile.

soil phases :
moderately eroded phase on very steep (over 60%) mountain slopes
severely eroded phase on extremely steep (over 100%) slopes

competing series : similar soils are found in the Gombong association of the foothills of the G. Kelud. Gombong soils have much less pumice gravel in the subsoils.

classification :

Mollic, Umbric and Typic Vitrandepts ashy over cindery, isothermic	- Soil Taxonomy
Mollic-Vitric and Melanic-Vitric Andosol	- LPT
Vitric-Melanic and Mollic-Vitric Andosol	- FAO/UNESCO

mapping units established :

Mk GKe	Gunung Kelud Complex, moderately eroded on very steep middle slopes of Gunung Kelud (total area: 393 ha)
Mk GKE	Gunung kelud Complex, severely eroded on extremely steep middle slopes of the Gunung Kelud (total area: 134 ha)

J JOMBOK SERIES

Jombok soils are well drained, very deep soils of steep hillslopes; they are developed in base-rich volcanic ash, locally redeposited or mixed with weathered tuff. Typically, the Jombok series have permeable and porous profiles with loamy, dark brown topsoils and clay loam, dark yellowish brown subsoils, generally with small amounts of pumice gravels or thin pumice layers.

A typifying profile is described in the annex.

setting : steep and very steep (30-75%) hillslopes. The soils are found between approximately 800 and 1000 meter above sealevel.

land use : most lands are within the forest boundary and are covered by natural degraded forest or scrub vegetation. Some land is used for agroforestry purposes.

topsoils : uneroded Jombok soils have 15-30 cm deep loamy topsoils, dark brown in colour. They have a well developed granular and subangular blocky structure, are porous and permeable and have 3,5-5% organic matter.

subsoils : the dark yellowish brown subsoils have a clayloam or clayey texture on handfeeling and a few subsoils show incipient clay illuviation. The structure is angular blocky. Most subsoils have up to 15% pumice gravels (1-3 cm Ø), or have thin bands or layers of pumice.

soil erosion : approximately 60% of the Jombok soils are moderately eroded (sheet, rill, locally a small gully), particularly where the soils are poorly terraced; non eroded soils are generally unterraced and under natural forest vegetation.

soil fertility : the soils are developed in base-rich materials and base saturation values are over 60% throughout (60-85%). However, some soils, subsoils in particular, are K-deficient. Plant available phosphorus is extremely low due to the high P-retention capacity of the soils. Organic matter levels vary from 3,5-5 % and the soils are very slightly acid (pH 6.0-6.5).

competing series : similar soils are in the Ngebrong, Kaumredjo and Kraantje Lek series. Ngebrong soils are morphologically very similar, but they are Andosols found above approximately 1000 meter. Kaumredjo soils are situated on the lower slopes and are developed in colluvial materials. Kraantje Lek soils are found in the Pudjon area, have very similar profiles but are low in bases and lack pumice gravel.

classification :

(Anthropic) Andic Hapludoll, fine clayey, locally loamy or medial, isohyperthermic	-	Soil Taxonomy
(Anthropic) Mollic-Andic Cambisol	-	LPT
(Anthropic) Andic-Haplic Phaeozem	-	FAO/UNESCO

mapping units established :

$\frac{Hs}{J}$ Jombok series on steep and very steep (30-75%) hillslopes (total area : 272 ha)

$\frac{Hs}{Jet}$ Jombok series, moderately eroded and strongly terraced (total area : 789 ha) on steep and very steep hillslopes

$\frac{Hs}{Jt}$ Jombok series, strongly terraced on steep (25-60%)hillslopes (total area : 149 ha)

JS JOMBOK-SELOREJO ASSOCIATION

An association of terraced, puddled and irrigated, often imperfectly drained soils of steep hillslopes in the area of Jombok. Originally all soils were loamy and clayloam Jombok soils, but strong terracing, bunding and puddling practices changed the properties of the soils considerably. Approximately 60% of the soils are still Jombok soils but with anthraquic properties (imperfectly drained, mottled and concretions and a rather dense traffic pan). The other 40%, particularly found on the lower slopes, are clayey and anthraquic Selorejo soils.

setting : steep 25-50% single hill and valley side slopes in the area of Jombok

land use : irrigated wetland rice cultivation with maize and horticultural crops in the dry season.

soils : see Jombok series and Selorejo series

erosion : moderate rill and small gully erosion, particularly between individual fields

classification :

Anthraquic Andic Hapludoll and Tropudalf fine clayey, isohyperthermic	- Soil Taxonomy
Anthraquic Mollic Cambisol and Mediteran	- LPT
Anthraquic Haplic Phaeozem and Luvisol	- FAO/UNESCO

mapping units established :

Hs	Jombok-Selorejo association, moderately eroded on steep
JSe	(total area : 146 ha) hillslopes

KC KALI KONTO COMPLEX

A complex of imperfectly drained, shallow, stony and bouldery soils of the Kali Konto river valley. They are generally terraced,irrigated and puddled and are developed in loamy alluvial materials derived from volcanic sediments.
The complex also include some deep loamy colluvial soils with uniform profiles and gradual boundaries.

A representative profile is described in the annex.

setting and land use : U-shaped valley of the Upper Kali Konto; the lands are generally terraced and used for rice or vegetable cultivation; farmers removed many stones from the soils.

soils : the soils are stony and bouldery and the majority are shallow; the effective soil depth varies from 10-50 cm. The soils have loamy, dark grayish brown topsoils and loamy, dark brown subsoils. The soils of the colluvial valley side slopes generally belong to the Sebaluh series.

soil erosion : some localized streambank erosion, deposition (colluvial)

soil fertility : the fertility of the soils varies, but most are well provided with nutrients. The organic matter levels, however, are moderate, ranging from 1-5%. Base saturation values as well above 50% with balanced ratios between the individual elements. The soils are slightly acid in the topsoil (pH 5.5-6.0) and very slightly acid in the subsoil (pH 6.0-6.9)

competing series : similar soils are in the Kali Pait complex, typical of concave river valleys. Most Kali Pait soils are deeper and have well developed profiles.

classification :

Anthraquic Eutropepts, Fluventic Tropohumults - Soil Taxonomy
and Dystropepts, loamy skeletal and loamy,
isohyperthermic
Anthraquic Eutric Cambisols - LPT and FAO

mapping unit established :

Au/KC Kali Konto Complex on flat valley floors
(total area : 126 ha)

PC KALI PAIT COMPLEX

A complex of imperfectly drained, shallow to deep, locally gravelly, stony or bouldery soils of concave river valleys. They are terraced, irrigated and puddled soils, developed in fine textured alluvial and colluvial materials derived from volcanic sediments.

setting : colluvial valleys of the middle Kali Konto river and its main tributaries; very gently sloping (3-8% slopes)

soils : the soils are developed in stony and bouldery alluvial materials covered by 30-80 cm fine textured sediments. They have dark grayish brown 10-30 cm deep topsoils, with a loamy texture and often with some gravel. The dark brown loamy subsoils may be stony or bouldery; many subsoils are dense as a result of puddling. Many soils are stratified.

soil erosion : locally some streambank erosion or some deposition

soil fertility : the fertility of the Kali Pait soils is very similar to that of the Kali Konto complex soils. The soils are slightly acid in the topsoil (pH 5.5-6.0) and very slightly acid in the subsoil (pH 5.8-7.0). the topsoils have 3-5% organic matter and a base saturation of over 50%.

competing series : similar soils are in the Kali Konto complex (shallow, bouldery and stony) classification :

Anthraquic Eutropept, Humitropept and Tropudalf - Soil Taxonomy
loamy, clayey or loamy skeletal, isohyperthermic
Anthraquic and Humic Cambisols and Mediteran - LPT
Anthraquic Cambisols and Luvisols - FAO/UNESCO

mapping units established :

Ac/PC Kali Pait complex in colluvial concave valleys (total area : 298 ha)

IC KALI PINJAL COMPLEX

A complex of well and somewhat excessively drained, deep and moderately deep soils, developed in mixtures of redeposited volcanic materials, including ash, tuff, pumice and cinders. Due to erosion, deposition and terracing, the soil properties may vary over short distances.

setting and landuse : small erosion valleys in the lower intervolcanic plain, with 15-40% single, straight, rather short slopes. The lands are sometimes used for dryland agriculture incl. gardens with mixed perennial crops; others are used for (agro)forestry or have a kirinyu vegetation

soils : the soils are well and somewhat excessively drained with a rapid runoff and permeability; many are rather droughty. The topsoil range from 10-20 cm, are dark brown or brown, have a sandy loam or loam texture and a weak developed structure. The subsoils are often gravelly or cindery and have a coarse loamy texture.

soil erosion : moderate to severe erosion (rill, gully and locally some streambank erosion)

soil fertility : though the soils are low in organic matter, eroded and droughty, they are developed in materials rather well provided with weatherable minerals. No exact data are known.

competing series : some Kali Pait soils resemble the soils of the Bendosari complex; the latter are developed in fine textured, gravelfree materials.

classification :

Typic Ustropepts, Ustic and Typic Dystropepts - Soil Taxonomy
Eutric and Dystric Cambisols - LPT and FAO

mapping unit established :

Pv/IC Kali Pinjal Complex, of small, steep incised erosion valleys (total area : 333 ha)

SA KALI SERENG ASSOCIATION

An association of loamy volcanic ash soils of dry lahar valleys. Approximately 50% of the association are deep, stratified and moderately well drained soils; the other 50% are shallow, stony and bouldery and excessively drained soils. Minor soils include shallow or moderately deep colluvial soils.

A representative profile of the deep soils is described in the annex.

setting : the association is typical of small U-shaped, usually dry lahar valleys, descending from the Gunung Kawi and the Anjasmoro Range. The longitudinal slopes are 5-12%.

soils : the deep stonefree soils consist of several layers of redeposited volcanic ash. Most sediments are loamy, but some are clay loam or sandy loam, with or without some small andesitic gravels. They are high in organic matter throughout the profile. The shallow, stony and bouldery soils are loamy, although some may be sandy loam or are gravelly. They have not well developed profiles, are relatively low in organic matter and are droughty.

soil erosion : locally there is some slight sheet erosion or deposition

soil fertility : the deep soils are well provided with cationic nutrients; base saturation values range from 60-90%, but the organic matter levels vary considerably (2-10%).
Most shallow soils have 2-3% organic matter, base saturation percentages between 40-65% and are acid to slightly acid (pH 4.7-5.5)

competing series : similar soils are found in the Kali Tlogo complex, which is typical of small colluvial valleys. The Tlogo soils are deep and generally stone and boulder free.

classification :

Udic, Lithic and Entic Eutrandepts — Soil Taxonomy
medial and medial skeletal, iso(hyper)thermic
Mollic and Mollic-Lithic Andosols — LPT and FAO

mapping units established :

Al/SA Kali Sereng Association of dry lahar valleys
(total area : 477 ha)

TC KALI TLOGO COMPLEX

A complex of deep, moderately well drained soils, typical of small concave colluvial valleys. The soils of this unit are developed in stratified layers of volcanic ash or sediments of variable textures and derived from volcanic materials.

A representative profile is described in the annex.

setting : small concave colluvial or alluvial valleys in the foothills of the Anjasmoro range and the Gunung Kawi mountain. Flooding is rare.

land use : some soils are intensively used for rainfed agriculture and horticulture; others are within the forest boundary and under a natural vegetation.

soils : most soils are stratified colluvial soils developed in alternating layers of loamy, sandy loam or clayloam sediments; some may be slightly gravelly or have thin gravel layers in the subsoils. Most soils are brownish or yellowish brown, but some may be darker. The sediments often contain appreciable amounts of organic matter that decrease irregularly with depth. In the upper parts of many of the valleys, the soils are developed in redeposited volcanic ash (andosols) with thickened topsoils.

soil erosion : locally some deposition or streambank erosion.

soil fertility : the fertility status of the Tlogo soils varies from fertile with high organic matter levels and high base saturation percentages to low or even deficient in several cationic nutrients (particularly in magnesium). Most soils are slightly acid (pH 5.0-5.5) to very slightly acid (pH 5.5-6.0), often increasing with depth.

competing series : none; soils of other concave valleys are stony, bouldery and shallow and belong to the Kali Sereng Association or to the Kali Konto and Kali Pait Complexes.

classification :

Fluventic Eutropepts; some Eutrandepts fine loamy, isothermic or isohyperthermic	- Soil Taxonomy
Eutric Alluvial soils; some Humic Andosols	- LPT
Eutric Fluvisol; some Humic Andosols	- FAO/UNESCO

mapping unit established :

$\frac{Ac}{TC}$ Kali Tlogo Complex of small concave colluvial valleys (total area : 120 ha).

K KAUMREJO SERIES

The Kaumrejo series are well drained, very deep, fine loamy soils of colluvial footslopes and foothills in the area of Ngantang.

They are developed in base-rich colluvial materials derived from volcanic sediments. The soils typically have dark brown, sandy clay loam topsoils and dark yellowish brown clay loam to clayey subsoils. Many Kaumrejo soils are somewhat gravelly in the subsoil and may have a buried profile.

A typifying profile is described in the annex.

setting : gently sloping and sloping (5-15%) concave colluvial footslopes and undulating to rolling colluvial foothills.

land use : nearly all lands are terraced and intensively cultivated with foodcrops (rainfed) or are mixed perennial crop gardens (coffee dominant).

topsoils : due to colluviation and intensive terracing, the topsoils vary considerably in depth (from 10-15 cm higher on the slopes and on the cut side of the terraces to between 25-45 cm on the lower parts of the slopes and on the fill side of the terraces). They have sandy clay loam to clay loam textures (22-37% clay), generally with some fine andesitic or pumice gravels and are well structured and porous.

subsoils : the dark yellowish brown subsoils have clay loam or clayey textures and blocky structures. Most subsoils have some fine or medium sized pumice or andesitic gravels, ranging from 5-30% (vol.). Some profiles show evidences of clay illuviation but laboratory data do not indicate enough clay increase for the horizon to become argillic.

soil erosion : non or slight rill erosion.

soil fertility : the Kaumrejo soils have 2,5-3% organic matter in the surface horizons, decreasing slowly and irregularly with depth. The soil reaction is very slightly acid to neutral; pH values range between 6.0-6.5 in the topsoils, increasing to approx. pH 7 in the subsoils. Base saturation is high, particularly in the subsoils, but some topsoils are low in potassium or have unfavourable Mg/K ratios. The soils are very low in available phosphorus and show a marked response to added P-fertilizers.

soil phases : a stony phase has been established on a relatively thin lahar flow

competing series : similar soils are in the Sebaluh series, found on colluvial footslopes in the Pudjon area. Sebaluh soils,however, have no gravel, are higher in organic matter but have lower base saturation values. The Kaumrejo soils are found in association with the Jombok series on the hillslopes just above the colluvial footslopes of the Kaumrejo soils.

classification :

Anthropic Andic Eutropept - Soil Taxonomy
fine loamy (loc.over cindery) isohyperthermic
Andic-Eutric Cambisol - LPT and FAO

mapping units establsihed :

Hc/Kt Kaumrejo series on colluvial footslopes or foothills (total area : 1149 ha)

Al/Ks Kaumrejo series, stony phase on sloping lahar land (total area : 22 ha)

KA KELET ASSOCIATION

The Kelet association groups the soils of the Gunung Kelet, a single eruption cone in the area of Pudjon. The cone rises from the inter-volcanic plain at approx. 1150 meter till an elevation of 1477 meters.

All soils are somewhat excessively drained, shallow or moderately deep, stony and bouldery and are developed in thin layers of volcanic ash overlying fragmented andesitic rocks. Under the present vegetation (forest) erosion is only slight.

The soils of the upper slopes, above approximately 1300 meter, are loamy young volcanic ash soils with dark coloured, humus-rich fluffy topsoils and brown loam to clay loam subsoils (stony Coban Rondo soils).

The soils of the middle and lower slopes are slightly more developed, loamy soils with 10-20 cm deep topsoils and moderately deep or shallow yellowish brown, loamy to clay loam subsoils (stony Kraantje Lek and Sebaluh soils).

The soils are slightly acid. Due to their low potential, they have not been studied and analyzed in detail.

competing series : the presence of stones, boulders and their position on a single volcanic cone make the Kelet soils unique, not comparable to any other soil unit in the area.

classification :

Typic and Lithic Dystrandept and Andic and Andic - Lithic Eutropept, medial over skeletal, isothermic - Soil Taxonomy

Humic and Humic-Lithic Andosol and Andic and Andic-Lithic Cambisol - LPT and FAO

mapping unit established :

Hi/KA Kelet association of the Gunung Kelet (total area : 62 ha)

L KRAANTJE LEK SERIES

The Kraantje Lek soils are very deep, loamy volcanic ash soils of the upper intervolcanic plateaux, plateaux remnants and dissected plains in the area of Pudjon - Purworejo. Typically, the Kraantje Lek soils have humus-rich fluffy topsoils and dark yellowish brown porous subsoils. They resemble the young volcanic ash soils (andosols) but they are slightly more developed and are actually intergrades to the more developed cambisols of the lower areas.

A typifying profile is described in the annex.

setting : intervolcanic upper plains and plateaux remnants in the area of Pudjon; they also occur on serrated (dissected) plateaux, in association with the soils of the Bendosari complex.

land use : most soils are rainfed agricultural lands; some are within the forest boundary and under scrub vegetation or used as agroforestry land.

topsoils : the surface horizons are 20-45 cm deep, very dark grayish brown in colour and with 5-8% organic matter. The texture is loamy on handfeeling and the structure very fine granular and subangular blocky, somewhat fluffy and very porous.

subsoils : the yellowish brown subsoils have a clay loam texture on handfeeling and a moderate blocky structure; they are porous and permeable. In some profiles there is a slight evidence of clay illuviation. Below 80-130 cm from the surface a buried older profile may be present.

soil erosion : slight splash erosion.

soil fertility : the soils are very slightly acid throughout (pH around 6.0) and are relatively well provided with cationic nutrients except magnesium, which is often low. Base saturation values of the topsoils vary from 25-40%; of the subsoils from 40-75%. The available phosphorus levels are moderate and there is a fairly strong reaction to added P-fertilizers.

competing and associated series : similar soils are in the Jombok, Coban Rondo and Pudjon series. The Jombok soils are found on lower hillslopes in the area of Ngantang and are developed in base-rich volcanic materials (high base saturation values) with some pumice gravels or gravel layers. Coban Rondo are morphologically very similar, but these are andosols and found above approx. 1250 meter. Pudjon soils are typical of the middle intervolcanic plains and have more developed B-horizons. The Kraantje Lek soils are found in association with the soils of the Bendosari complex on serrated (dissected) plains in the area of Bendosari -Purworejo.

classification :

Andic Humitropept, medial isothermic	- Soil Taxonomy
Andic Cambisol	- LPT and FAO/UNESCO

mapping units established :

Pu / L	Kraantje Lek series on gently sloping upper plains and plateaux remnants	(total area : 387 ha)

LU LUKSONGO ASSOCIATION

An association of soils of the Luksongo hills, West of the Selorejo Lake. The hills are very steep with rock outcrops and scarps.

Approximately 30% of the area are scarps with rocks or very shallow lithosols. Sixty percent of the remaining area is covered by soils of the Ngebrong and Jombok series; they are situated on the upper slopes and crests. The remaining soils are similar to many of the Bendosari soils (eroded soils developed in mixtures of redeposited volcanic ash and tuff), while on the lower slopes a few soils are in the Kaumrejo series.
For detailed descriptions, see the individual soils of the association (paragraphs IV.2, IV.10 and IV.17).

The Luksongo hills are within the forest boundary and are covered by a degraded forest or scrub vegetation.

mapping units established:

Hs / LU	Luksongo association on very steep hills with rock outcrops and scarps	(total area : 255 ha)

NA NGANTANG ASSOCIATION

An association of well drained, very deep, dark coloured soils developed in base-rich materials derived from volcanic ash, and found on the lower intervolcanic plains.
Approximately 60% of the soils of the association belong to the Ngantang series with clayloam topsoils and clayey subsoils. The remaining soils are in the Jabon series with sandy clay loam topsoils and loam to clayloam subsoils.

Typifying pedons of the two series are described in the annex.

setting : the association is found exclusively on the very gently sloping lower intervolcanic plains around Lake Selorejo.

landuse : dryland agriculture (maize dominant) and perennial crop gardens with coffee, clove, coconut, vanilla, banana, kapòk and other perennials.

topsoils : both series have well structured, porous and permeable topsoils, 20-40 cm deep and very dark brown in colour. The Ngantang topsoils have clayloam textures (30-38% clay), the ones of the Jabon series sandy clayloam textures (22-35% clay). Many Jabon soils, particularly South of the Selorejo lake, have some pumice gravels in the topsoils.

subsoils : the subsoils of the Ngantang series are clayey with clear evidence of clay illuviation (argillic horizons). The Jabon series have subsoils which vary in texture from loam to clayloam and sandy clayloam, often with some pumice or andesitic gravels. The Jabon soils have a weak developed buried soil, below 60-80 cm from the surface.

soil erosion : -

soil fertility : the soils are rather low in organic matter, generally not exceeding the 2% level.They are very slightly acid (pH generally always above 6.0 throughout) and as they are developed in base-rich parent material, they are well provided with nutrients. Base saturation is invariably above 50% and in many soils above 65%.

soil phases : -

competing series : similar soils are in the Jombok and Ngantru series. The Jombok series are found on the hillslopes in the same area as the Ngantang association, are higher in organic matter and have low bulk densities. The Ngantru series are also found on the lower volcanic plains. These soils resemble the Jambon series but are much more sandier (sandy loam versus sandy clay loam to clay loam) and are characterized by considerable amounts of volcanic pumice gravels.

classification :

Ngantang series

Typic Agriudoll, clayey, isohyperthermic	- Soil Taxonomy
Mollic Mediteran	- LPT
Luvic Phaeozem	- FAO/UNESCO

Jabon series

Fluventic Hapludoll fine loamy, isohyperthermic	- Soil Taxonomy
Mollic Cambisol	- LPT
Haplic Phaeozem	- FAO/UNESCO

mapping units established :

$\frac{\text{Pl}}{\text{NA}}$ Ngantang association on lower intervolcanic plains (total area : 1.219 ha)

G NGANTRU SERIES

The Ngantru series are well drained, deep, coarse loamy soils, developed in a succession of layers of coarse and fine textured volcanic sediments originating from the Gunung Kelud. They are found on the intervolcanic lower plains. Typically, the Ngantru soils have sandy loam topsoils with variable amounts of small pumice gravels and subsoils consisting of buried older profiles. Each buried profile represents a major eruption cycle of the Gunung Kelud.

A typifying profile is described in the annex.

setting : lower intervolcanic plains and plateaux in the area of Ngantru, very gently sloping

landuse : dryland agriculture with maize, cassava, tobacco as dominant annual crops and banana, coffee, coconut, kapok and clove as codominant perennials, the latter generally grown on the divisions of individual fields.

topsoils : the topsoils vary in depth from 15-30 cm, are sandy loam with variable amounts of pumice gravels up to 4 cm in diameter. Originally, the topsoil consisted of a 15-20 cm deep (All) horizon with 10-25% pumice gravels in a thin Al2 horizon with 60-80% pumice gravels. In many instances however, the two subhorizons have been mixed. The mixtures are dark brown to brown and have 2-2.5% organic matter. Soil structure is often weak.

subsoils : the subsoil consists of a buried profile with a 15-25 cm deep sandy loam A horizon with very few pumice gravels, followed by a structural sandy B- horizon. The amounts of gravel increase with depth from 1-2% to 20-40%. Below 100-110 cm from the soil surface a second buried profile is found, again with few pumice gravels in the topsoil which gradually increases in amount with depth. The boundaries between the various horizons are clear or abrupt.

soil erosion : -

soil fertility : typically, the soils are rather low in organic matter (1.5-2.5%). The soil reaction is only slightly acid (pH 6.0-6.5). Base saturation values vary within and between profiles from 50-80%. Some soils are low in phosphorus and some also in potassium or magnesium due to an imbalance between the elements.

soil phases : -

competing series : similar soils are in the Gombong association found on the middle slopes of the Gunung Kelud. The Gombong soils are Andosols and have much more pumice gravels (gravelly soils).

classification :

Andic Hapludoll, coarse loamy, isohyperthermic	- Soil Taxonomy
Mollic-Andic Cambisol	- LPT
Andic Phaeozem	- FAO/UNESCO

mapping unit established :

Pl/G Ngantru series on gently sloping lower intervolcanic plains (total area : 497 ha) in the G. Kelud area

N NGEBRONG SERIES

The Ngebrong series are deep and very deep young volcanic ash soils of the steep hill and mountain slopes. Typically, the Ngebrong soils have well drained, permeable, porous and loamy profiles with near-black, humus-rich, fluffy topsoils and dark (yellowish) brown subsoils. Many soils have some pumice gravels in the subsoil and some even a gravelly pumice layer or lens. The Negbrong soils are developed in base-rich volcanic ash and have large amounts of available cationic nutrients.

A typifying profile is described in the annex.

setting : steep hill and mountain slopes, small hill plateaux, mountain spurs and crests of the Anjasmoro mountain range and the western slopes of the Gunung Kawi. The soils are found above 1000 meter approximately.

landuse : natural and degraded mountain forest, kirinyu scrub vegetation and locally some plantation forests or agroforestry plantings.

topsoils : the Ngebrong soils have 20-40 cm deep black or very dark brown topsoils, rich in organic matter (7-15%). Some soils have topsoils as deep as 70-80 cm (generally including buried older topsoils). The texture on handfeeling is loamy with pseudosands of clotted ash particles and the soils have a fluffy, granular and subangular blocky structure and very low bulk densities.

subsoils : the subsoils are dark brown, dark yellowish brown or sometimes very dark brown with black or very dark coloured buried profiles; the latter are often found below 70-100 cm from the soil surface. The texture of the subsoil is clay loam to loam on handfeeling. Many Ngebrong subsoils have 1-5% fine andesitic gravel or pumice gravels. Some Ngebrong soils may even have a layer or lens consisting almost exclussively of fine and medium pumice gravels. This layer, if present, is generally found below 70-80 cm from the soil's surface. The structure of the subsoil is angular and subangular blocky, is very porous and permeable with low bulk densities.

soil erosion : approx. 65% of the Ngebrong soils are not or only slightly eroded (splash or rill); approx. 25% are moderately eroded (rill or natural slip erosion), while the remaining 10% are severely eroded (natural slip and flow erosion).

soil fertility : the Ngebrong series are developed in base-rich volcanic-ash and are well provided with available and cationic nutrients, except magnesium which often is low and deficient. There also may be an Mg/K imbalance. Base saturation is over 50% throughout the profile. The soils are high in organic matter (7-15%) and are only very slightly acid (pH generally above 6.0). The Ngebrong soils are fairly low in available phosphorus, with high capacities to retain and fix Phosphorus.

soil phases :
- moderately eroded phase, on steep and very steep hill and mountain slopes
- moderately eroded and strongly terraced phase on steep and very steep hill slopes
- severely eroded phase on very steep and extremely steep mountain slopes
- severely eroded and strongly terraced phase on very steep and extremely steep hill and mountain slopes
- strongly terraced phase on steep hill slopes

competing series : similar soils are in the Coban Rondo, Gunung Butak and Jombok series. Coban Rondo and Gunung Butak soils are andosols as well, but they have much lower base saturation values; the Gunung Butak soils also have a 5-10 cm thick organic topsoil layer. Jombok series are found below approx. 1000 meter and are slightly more developed.

classification :

Udic Eutrandept, medial isothermic (locally medial over cindery)	- Soil Taxonomy
Mollic Andosol	- LPT and FAO/UNESCO

mapping units established :

Hc/N	Ngebrong series, on 5-15% concave footslopes (total area : 167 ha)
Hp/N	Ngebrong series, on small hill plateaux and crests (total area : 354 ha)
Hs/N	Ngebrong series, on 30-75% hillslopes (total area : 2.763 ha)
Hs/Ne	Ngebrong series, moderately eroded, on 50-75% hillslopes (total area : 1.151 ha)
Hs/Net	Ngebrong series, moderately eroded and strongly terraced on 30-75% hillslopes (total area: 1.286 ha)
Hs/NEt	Ngebrong series, severely eroded and strongly terraced on very steep (50%) hillslopes (total area : 72 ha)
Hs/Nt	Ngebrong series, strongly terraced, on 25-60% hillslopes (total area : 4.056 ha)
Ms/Ne	Ngebrong series, moderately eroded, on 50-125% dissected mountain slopes (total area : 411 ha)

Ms/NE Ngebrong series, severely eroded on strongly dissected mountain slopes (over 100%) (total area : 1.166 ha)

Mu/N Ngebrong series, on 40-75% convex mountain spurs (total area : 52 ha)

P PUDJON SERIES

The Pudjon series are typical of the non irrigated upper plains. They have well drained, very deep, loamy profiles, developed in base-rich colluvial materials derived from volcanic ash. The soils typically have uniform homogeneous profiles with gradual horizon boundaries.

A typifying pedon is described in the annex.

setting : gently sloping middle plains in the area of Pudjon, between 950-1150 meter

landuse : intensively used for dryland agriculture and horticulture

topsoil : due to intensive terracing, the dark brown topsoils vary in depth from 15-40 cm. They have a loamy texture (20-30% clay) and have a fine and friable granular and subangular blocky structure.

subsoils : the subsoils are also dark brown and loamy and generally have a weak blocky structure. A buried profile is common; the buried soil has an incipient textural B-horizon and a weak prismatic structure

soil erosion : some slight splash or rill erosion

soil fertility : the Pudjon soils have 2.5-4% organic matter in the surface horizon, decreasing slowly and irregularly with depth. The soils are very slightly acid with pH values between 5.8-6.5 throughout. The soils are well provided with cationic nutrients and base saturation values range from 50-75%. Some Pudjon soils, however, are rather low in potassium or have unfavourable K/Mg and Ca/Mg ratios. The soils show a marked response to added P-fertilizers

soil phases : -

competing series : similar soils are in the Sebaluh series, found on colluvial footslopes and foothills in the same area. The Sebaluh series have well developed A and B horizons and are higher in organic matter.

classification :

Anthropic Andic Eutropept, medial isohyperthermic- Soil Taxonomy
Anthropic-Eutric Cambisol - LPT and FAO

mapping unit established :

Pm/P Pudjon series on gently sloping intervolcanic middle plains (total area : 659 ha)

B SEBALUH SERIES

The Sebaluh series are well drained, humus-rich soils of the colluvial footslopes. They have very deep, fine loamy profiles and are developed in base-rich materials derived from volcanic ash. The soils typically are dark coloured throughout and have clayloam to loam, humus-rich topsoils and clayloam subsoils.

A typifying pedon is described in the annex.

setting : gently sloping and sloping (5-12%) colluvial footslopes and undulating to rolling colluvial foothills.

landuse : nearly all lands are intensively cultivated with rainfed food- and horticultural crops.

topsoils : the topsoils are 17-45 cm deep, the variation being due to cut and fill practices (terracing). The surface horizons have dark or very dark brown colours, 3-5% organic matter, are well structured and have a loam to clayloam texture (25-30% clay).

subsoils : the subsurface horizons are generally dark yellowish brown, still relatively rich in humus and have well developed blocky structures. Many profiles show evidence of clay illuviation but laboratory data do not indicate enough clay increments for the horizons to become argillic.

soil erosion : the central concept of the series is not eroded; a moderately eroded phase has been recognized with moderate rill and some gully erosion.

soil fertility : the fairly high organic matter levels (3-5%) are characteristic; the soil reaction is slightly acid in the topsoil (pH 5.3-5.8) and very slightly acid in the subsoil (pH 6.0-6.8). Base saturation varies from 35-55% in the topsoil, increasing to 45-80% in the subsoil. The soils show a strong reaction to added P fertilizers.

soil phases : there is a moderately eroded phase on 8-15% sloping footslopes or on rolling foothills (rill and small gully erosion between the terraced fields). The eroded phase is also found on the steep slopes of the small Gunung Amping-Amping.

competing series : the Sebaluh series resemble the Pudjon series found on the intervolcanic middle plains. The Pudjon soils have less organic matter and less developed subsoils (B-horizons). The Sebaluh series also resemble the Kaumredjo series, also found on colluvial footslopes. The Kaumredjo soils have some gravel, have less organic matter but most are higher in base saturation.

classification :

(Anthropic) Andic Humitropept, loamy, silty or medial, isohyperthermic - Soil Taxonomy

(Anthropic)-Andic Cambisol - LPT and FAO

mapping units established :

Hc/B Sebaluh series, on 5-12% gently sloping to sloping colluvial footslopes (total area : 233 ha)

Hc/Bet Sebaluh series, moderately eroded on 8-15% sloping colluvial footslopes or rolling colluvial foothills (total area : 118 ha)

Hi/Bet Sebaluh series, moderately eroded on 30-60% slopes of the Gunung Amping-Amping (total area : 43 ha)

S SELOREJO SERIES

Selorejo series comprise the padi soils around Lake Selorejo. They have imperfectly or poorly drained, deep profiles, developed in sandy clay loam to clayey volcanic materials. The topsoils are being puddled, are dark coloured and have a sandy clay loam texture. The subsoils are dense, clayey, dark coloured with mottles, concretions and some faint gley characteristics.

A typifying profile is described in the annex.

setting : the Selorejo series are situated in the lower intervolcanic plains surrounding Lake Selorejo, at elevations between 620 meter (the level of the lake) and 800 meter approximately.

landuse : most lands are intensively used for wetland rice based cropping systems

topsoils : the surface horizons are 15-25 cm deep, dark grayish brown in colour and have a sandy clay loam to clay loam texture (28-35% clay), with 1-3% coarse, sand-sized pumice particles or fine pumice gravels (2-3 cm Ø); almost all topsoils are puddled for wetland rice cultivation and the transitional horizon to the subsoil is often dense, compact and sometimes even somewhat cemented with mottles and concretions (a traffic pan).

subsoils : the subsoils are clayey (38-50% clay) and there is evidence of clay illuviation (argillic horizon). The structure is mostly coarse or medium angular blocky to weakly prismatic and rather dense and compact. The colour of the subsoil is dark grayish or dark yellowish brown with many distinct Fe and Mn mottles and concretions and weak gley colours. Below 70-90 cm there is sometimes a weakly or moderately cemented hardpan, particularly in soils with some medium and coarse pumice particles (cement structures).

soil erosion : slight gully erosion between the sawahs; an eroded phase has been identified.

soil fertility : the Selorejo soils have moderate amounts of organic matter (2-4%), but being developed in base-rich parent materials, most cationic nutrients are in good supply, particularly calcium and magnesium; an exception is potassium which generally is low and in some instances very low. Also the available phosphorus levels are low and the soils respond well to P-fertilization. The soil reaction is very slightly acid throughout (pH 5.8-6.5).

soil phases : a moderately eroded phase has been recognized on 8-20% slopes; erosion consists of gully erosion between the sawah fields, as well as erosion due to the collapse of sawahs after heavy rains.

competing series : similar soils are in the Tawangsari series. Tawangsari soils are also "padi" soils (although most are used for irrigated horticulture) in the area of Pudjon. Tawangsari soils have higher base saturation values (> 50%) and lack pumice particles.

classification :

Anthraquic Tropudalf, fine clayey, isohyperthermic	-Soil Taxonomy
Anthraquic Mollic Mediteran	-LPT
Anthraquic Luvic Phaeozem	-FAO/UNESCO

mapping units established :

Pl/S	Selorejo series on gently sloping (3-8%), intervolcanic lower plains (total area : 587 ha)
Pl/Se	Selorejo series, moderately eroded, on sloping (8-15%) lower volcanic plains (total area : 274 ha)
Hc/St	Selorejo series, strongly terraced, on 5-15% concave footslopes (total area : 176 ha)

SS SLIP SURFACES AND LANDSLIDE SCARS
(miscellaneous land type)

This unit concerns a miscellaneous land type of landslide surfaces and scars, i.e. consisting mostly of masses of soil material, weathered andesitic rock, coarse stony and rocky debris and other unconsolidated material that slid down continuously. The materials move down under forces of heavy rain and gravity. The unit is found on extremely steep upper slopes of the mountain complexes and hills. The mass movements are entirely natural.

The soils are a complex of very shallow, stony and bouldery regosols and "non" soils. The unit has not been studied in detail.

T TAWANGSARI SERIES

Typically, Tawangsari series are "padi" soils with imperfectly drained, deep, terraced and puddled profiles, developed in base-rich clayey materials derived from volcanic ash. The soils have thick and dark coloured surface horizons and dense clayey (argillic) subsurface horizons. The Tawangsari soils are found on the intervolcanic plains of Pudjon.

A typifying pedon is described in the annex.

setting : the Tawangsari series are found on the intervolcanic middle plateaux and plains; 950-1175 meter above sealevel (Pudjon area).

landuse : all lands are intensively used for irrigated agriculture and horticulture, including some wetland rice cultivation and horticultural crops.

topsoils : the topsoils are 25-35 cm deep, very dark grayish brown and have a clay loam to clayey texture with 28-44% clay and a favourable, friable, granular and subangular blocky structure. The transitional horizon to the subsoil is often dense with mottles and concretions (a traffic pan due to puddling).

subsoils : the subsoils are dark brown or dark grayish brown and clayey (33-50%), with clear evidences of clay illuviation (argillic horizon). The structure is prismatic and rather dense and compact with a slow permeability. In the deeper subsoil there is often a weakly developed buried profile.

soil erosion : slight gully erosion between the terraced fields; an eroded phase has been recognized as well.

soil fertility : the soils have moderate amounts of organic matter (2-3.5%). However, they are well provided with nutrients, but phosphorus may be rather low in some Tawangsari soils. The soil reaction is slightly acid in the topsoils (pH 5.0-5.7) and very slightly acid in the subsoils (pH 5.8-6.5).

soil phases : moderately eroded phase on 8-20% slopes; erosion generally due to the collapse of sawahs and between the individual fields. The eroded soils have less deep topsoils (15-30 cm).

competing series : similar soils are in the Selorejo series, typical of the intervolcanic plains below 800 meter. Selorejo series have some coarse sand or fine pumice gravel and have lower base saturation values.

classification :

Anthraquic Argiudoll, fine clayey, mixed?, isohyperthermic	- Soil Taxonomy
Anthraquic Mollic Mediteran	- LPT
Anthraquic Luvic Phaeozem	- FAO/UNESCO

mapping units established :

Pm/T	Tawangsari series (total area : 741 ha)	on gently sloping 3-8% intervolcanic middle plains and plateaux
Pm/Te	Tawangsari series, moderately eroded (total area : 315 ha)	on sloping and moderately steep middle plateaux

SECTION V. EROSION

V.1. EROSION IN PERSPECTIVE

Soil erosion, with its many impacts on utilizable land resources and environmental quality, represents a major threat to land productivity and human welfare. It is also a relentless process that is nearly impossible to stop, usually difficult to control and easily accelerated by man.

By definition, soil erosion is the removal of soil material by water or wind. In the Kali Konto watershed, soil erosion by water is the most active and in this section we will centre the discussions on water (rainfall) erosion. This does not mean that there is no winderosion in the area. The loamy soils, themselves formed in windblown materials (ash), are very liable to wind erosion as anybody will realize who has been in the area during a quiet and warm afternoon in the dry season, when loose surface soil material is picked up by the small warm-weather whirlwinds and blown high into the sky. But generally speaking, situated in the rather humid tropics where strong winds are rare, wind erosion is less significant.

Quantitative determinations of the extent and impact of soil erosion by water in tropical areas are sketchy and till the last decade, the area of the Kali Konto watershed was no exception. Then, during the late sixties, the Selorejo dam was constructed. The engineers in charge of the planning of the dam based their calculations on an average deposition rate in the Lake of approx. 270.000 m^3/year, corresponding to 1.2 mm of soil per year as an average for the whole watershed (Brabben, 1978). The figure of 1.2 mm is already high, but not unusual in Java. In 1977, a reservoir study was carried out to determine the volume of sediment deposition in the Lake from 1970-1977. The study indicated that the volume of sediment in that period was approx. 730.000 m^3/year, corresponding to an average erosion of over 3 mm/year for the entire watershed. Although recent studies indicate lower values, the actual sedimentation is much higher than previously assumed.

Another way to assess and evaluate the seriousness of the erosion problem, is to consider the soils themselves and to evaluate the degrading effects of soil erosion on the agricultural production capacity of this precious resource. Most soils in the area are the result of a gradual and continuous process of accumulation of fresh volcanic ash, rich in weatherable minerals. This process resulted in very deep soils with subsoils having often similar levels of soil fertility (and production capacity) then the topsoil. Removal of soil material by water will thus often have a limited effect and realizing this, it is then clear that the threshold level, or the limit of "tolerable" erosion, for the agronomist and the farmer is of a different magnitude than that for the hydrologist in charge of the Selorejo dam.

A third aspect of soil erosion is natural erosion, being the normal aspect of landscape development and which concerns the geomorphologist. Natural erosion (others use the term "geologic erosion" or "normal erosion") is an active process in geologically very young areas with alternating periods of denudation and renewed volcanic activity. Clear evidence of high rates of natural erosion in the Kali Konto area, not only in the highest, extremely steep mountainous parts, but also in the agricultural areas, proves that natural erosion is indeed an active process. For example, the process of headward gullying of the Kali Konto river system in the intervolcanic plains, resulting in deep and wide erosion valleys with very steep valley-side slopes (units Ps on the landform map), affected and degraded already over 35% of the plain.

From the above we see that assessment of the seriousness of erosion in the area may lead to contradictory statements. The complex nature of the problem is well brought up by (i) the hydrologist with his alarm that "erosion" must be controlled as otherwise the value and function of the Selorejo dam will be in danger, (ii) the geomorphologist with his statement that natural erosion is considerable and cannot be stopped and (iii) the agronomist and farmer who do not easily see the effects of erosion within the individual farmer's fields and who may reason that whatever the rainstorms will take away, will be replaced by an occasional eruption of a nearby (or far away) volcano.

V.2. FORMS AND EXTENT OF EROSION

Natural and Accelerated Soil Erosion

In humid tropical environments, a young landscape as that of the Kali Konto area, with several recent volcanic complexes standing out high above the surrounding landscape, dissects rapidly. Dissection results in steep-sided valleys, where land-slides, rock-fall and other types of rapid mass movement are active as a highly effective process of denudation. Once the slopes are reaching a certain angle, the process of mass movement slows down and slopes become stable. The "threshold slope angle" is broadly related to the properties of the parent rock and sediments, the climatic and hydrologic conditions and the vegetation cover.

Once the slopes are at stable gradients with respect to rapid mass movement, the slower process of soil erosion becomes dominant.

Where rainfall cannot infiltrate sufficiently into the soil, it flows over the surface and gradually erosion starts to develop a drainage system in the area. In natural landscapes, erosion is also natural and may either be a gradual process or a rapid catastrophic one. Rapid geologic uplifting or new showers of volcanic ash that kill the natural vegetation will disrupt the equilibrium and initiate new cycles of very active erosion. Periods with rapid natural erosion will thus alternate with relatively stable periods with little natural erosion.

Man's activities may also disturb the natural equilibrium, resulting in a man-induced acceleration of the erosion process. Commonly, in applied soil science it is this accelerated soil erosion what is meant with the terms "soil erosion" or "erosion".

The distinction between natural erosion and accelerated soil erosion is an important one. Natural erosion is a process of soil and landform development, whereas accelerated erosion reduces the value and even destroys valuable farmland. In some areas natural and accelerated soil erosion are taking place simultaneously and it is often not easy to determine the relative importance of the two types.

Erosion in the Forest Areas

Most of the forest lands are situated on the steep volcanic mountainous and hilly complexes. On these surfaces, covered by rather thick packets of fairly loose, incoherent volcanic ash, mass movement (landslides, earthslips, creep or slopewash) is the principal and natural process of denudation and downslope movement of loose material. The term implies that gravity is the driving force, but water does play an important role. High concentrated rainfall saturates the regolith in the wet season, and act as a lubricant which triggers the process of rapid mass movement. The presence of less permeable layers of weathered rock or tuff or even a few single boulders are also important factors in landslide develoment.

Landslides and earthflows are the most spectacular forms of mass movement and can be observed frequently on the steepests slopes of the Kawi and Anjasmoro. They are less frequent on the Kelud which is build-up entirely of very porous pumice gravels. Slope gradient is an important factor and most landslide surfaces occur on slopes over 100%. On slopes over approx. 125-150% very little loose material will remain at all and these surfaces are actually subject to a continuous process of downslope movement. Vegetation on these surfaces is sparse and of a pioneer type (not scrub).

Earthslips are less spectacular and sometimes also a less rapid form of mass movement. Earthslips are less deep, removing only the soil and some underlying material over a slipping surface. Many of the earthslips are only a few meters in width and 10-50 m in length. Slip erosion is common on slopes over 60%, both under forest and scrub vegetation.

The slowest form of mass movement is creep erosion, measured only in centimeters per year. It can hardly be observed and measured directly, but the occurrence of curved tree trunks are a good indication of the existence and importance of the process. Soil creep is the principal form of mass movement on forested slopes with gradients up to 60%. Slopewash is a form of creep erosion.

The incidence of slopewash and also the more rapid forms of mass movement are said to increase with an increased degradation of the natural forests. The remark questions the protective capacity of the various vegetative covers found in forest lands. Although earthslips in scrub areas are indeed common and they can easily be spotted and observed, also from a comfortable position as a verandah chair on a leisurely afternoon, the soil survey team observed many slides and slumps under the closed canopy of the forest vegetation, where they appear to take place rather slowly without sudden tree falls. Studying different slides, slips and slopewash in the area, also in relation to the vegetation, it seems likely that local conditions of slope steepness and the presence of bedrock, tuff or other less permeable layers which can act as failure surfaces, are the principle factors in the occurrence of mass movement. These layers cannot absorb enough percolation water, so that the overlying mass becomes saturated and starts to slid down, independent of the vegetation. Only the form differs. An exception on the general rule may be the bushfire prone cemara forests. The lack of a continuous and dense undergrowth in this type of forest causes slopewash to become particularly strong in this forest type.

Erosion in the Agricultural Areas

When considering erosion in the agricultural areas of the watershed, a distinction must be made between the irrigated areas and the non-irrigated tegallan lands.

In areas where sufficient irrigation water is available, generations of farmers have remodeled the landscape by carving cascading terraces in the hillslopes. Through extensive irrigation systems each terrace is irrigated, one flowing into the next as in a rhytmic pattern.

Almost all sawah soils are strongly modified by puddling and irrigation, resulting in the formation of impermeable "traffic-pans", giving these soils their typical "padisol" or "anthraquic" character. During heavy, high intensity rainstroms, the sawahs cannot absorb all the rain and overflow is common. Most of the overflow will enter the next sawah, already overflowing by itself, and this self-accelerating process will lead to a point where the overflow will force its way in a concentrated form over the small footpaths or other strips of land between the sawah systems, resulting in gully erosion. Depending on the general slope gradient, slope length as well as the lay-out of the sawah systems, gully erosion in sawah areas can be considerable.

Sawahs or irrigated terraces on the steeper hillslopes with slope gradients of approximately 12% or over, may, under certain conditions also be subject to slumping. After long and persistent rains a whole series of sawahs breaks loose from its bed and slids downslope as a single unit. The surface of failure beneath a slump block is spoon-shaped, concave upward and outward. At the lower end a small earthflow may emerge, destroying an additional number of sawah structures downslope. Although farmers reconstruct their sawahs again, a particular relief remains visible, also known under the name of "catsteps".

In the tegallan lands the main factors determining soil erosion are (i) the permeability and infiltration capacity of the soils, (ii) the way terraces are constructed (management factor) and (iii) slope characteristics.
Of the three factors the permeability and infiltration capacities of the soils appear to be the most determinant. It is true that most tegallan soils are deep or very deep and have moderate to high infiltration capacities, but in many farmers' fields plowing and other soil preparation practices resulted in the formation of plowpans. Plowpans are particularly formed in loamy soils and many tegallan soils are very sensitive to the formation of these pans. Also tegallans which in the past were (occasionally) irrigated may still show a traffic pan (puddled, dense and with a low permeability) and are thus highly susceptible to erosion.

Erosion on tegallan land generally starts in the form of rill erosion. This occurs particularly during the first rains, when the soils are dry and very dispersible. It also occurs in the midst of the rainy season, when the amount of rain cannot be absorbed fully. However, as the fields are terraced and small, much of the removed soil will initially be trapped in hedgerows. Farmers will then obliterate the rills by tillage, but where the rills are many, the practices often result in a deterioration of the terraces as well. The latter become irregular, sloping and, instead of acting as a medium for water conservation, they tend to concentrate run-off water, encourage the formation of new rills and, where the slopes are long enough, gully erosion at the lower end. Rill and gully erosion in tegallans, and particularly in tegallans which, now or in the past, are (were) occasionally irrigated, are one of the most active forms of accelerated erosion in the area.

Another important origen of erosion in the agricultural areas are the agro-residential areas and the dense network of roads and footpaths. In the villages there are generally no provisions to collect rainwater and as the soils around the houses are usually bare and dense and have low infiltration capacities, most of the water of intensive rainstorms will flow overland. As nearly all villages are situated on more or less sloping land, the resulting streams of water leaving the villages have enormous erosive powers and the loosened sediment often moves as a slurry, first to the roadside ditches and from there to the major streams. No data are known of soil loss and run-off from agro-residential areas and from roads and footpaths. But the fact that 20% of the agricultural areas are actually residential village areas, suggests that the contribution of this particular form of run-off and erosion must be high. A conservative estimate of the contribution of 20% urban village area and another 3-4% for footpaths, farm roads, roadsides, etc., to the total amount of runoff and sediment yield in Lake Selorejo is between 40-60% for runoff and between 20-40% for sediment yield.

The certainly somewhat speculative estimates suggest however, that much more attention should be paid to the problems of the impact of urban village areas and rural roads to run-off, erosion and sediment yield. This is particular true for the latter as the phenomena are usually not reflected in a greater land degradation or lower land productivity. Careful consideration also needs to be given to the local practice of cultivating roadsides, irrigation canal ditches etc.

Soil Erosion Maps

For the purpose of land use and conservation planning an actual (present) erosion map and an erosion susceptibility map have been prepared of the watershed, both at a scale 1:50.000 (coloured maps 3A and B and fig. V.1. and V.2.).

The actual or present erosion map is derived from the 1:20.000 soil map. As discussed in Section III (Soil Survey Procedures) particular attention has been paid to soil erosion features, both form and intensity, and many mapping units of the 1:20.000 soil map and the result of differences in erosion.
The map indicates for each mapping unit the predominant type of erosion: natural creep, slip or flow erosion, accelerated sheet rill or gully erosion, or a combination. It also indicates the erosion intentsity (slight, moderate, severe), but not in absolute terms. Instead, in assessing the degree of erosion, the criteria used are the proportion of the area affected and the degree of degradation of the soil's agricultural potential resulting from erosion. For details, see chapter III.4.

The erosion map shows in an overview that, concerning erosion, the area can be divided roughly in three different zones:

In the highest parts of the watershed natural erosion, generally in the form of mass movement, is an important and natural process of denudation. Most of the loose erosion products, however, remains as a debris on the footslopes and lower parts of the steep mountains. Only very occasionally, after very heavy and persistent rain together with a major landslide, a cold rain lahar or debris (mud) flow may remove the loose debris to the lower parts of the watershed. The landform and soil map, however, indicate that these lahars only rarely reach the river system of the Kali Konto. The natural erosion in the highest parts of the watershed will thus not contribute directly to the large amounts of sediment deposited in the Selorejo reservoir.

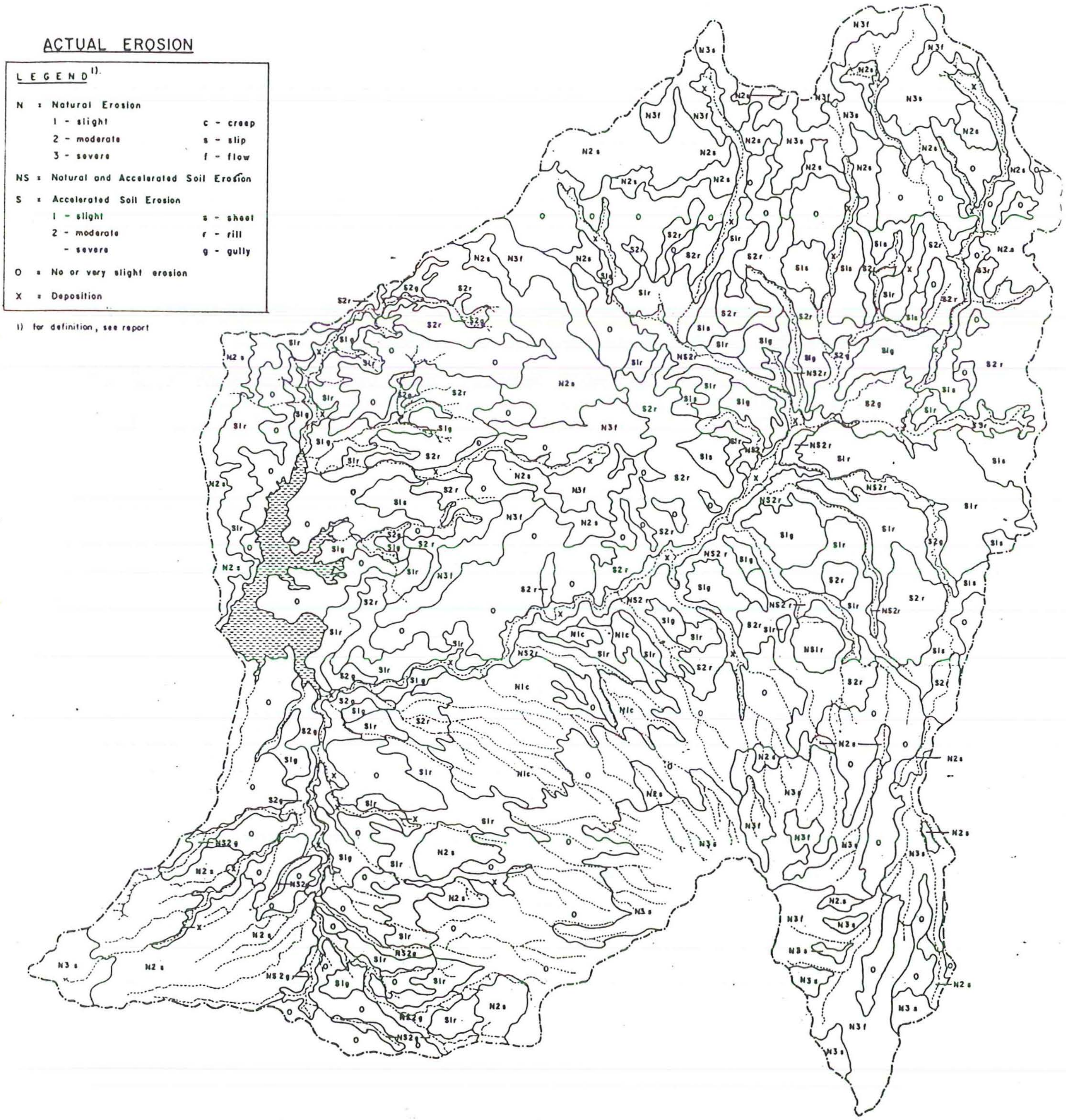

Fig. V.1. Generalized actual erosion sketch map Kali Konto Watershed (not to scale) (reduction of the 1:50.000 actual erosion map)

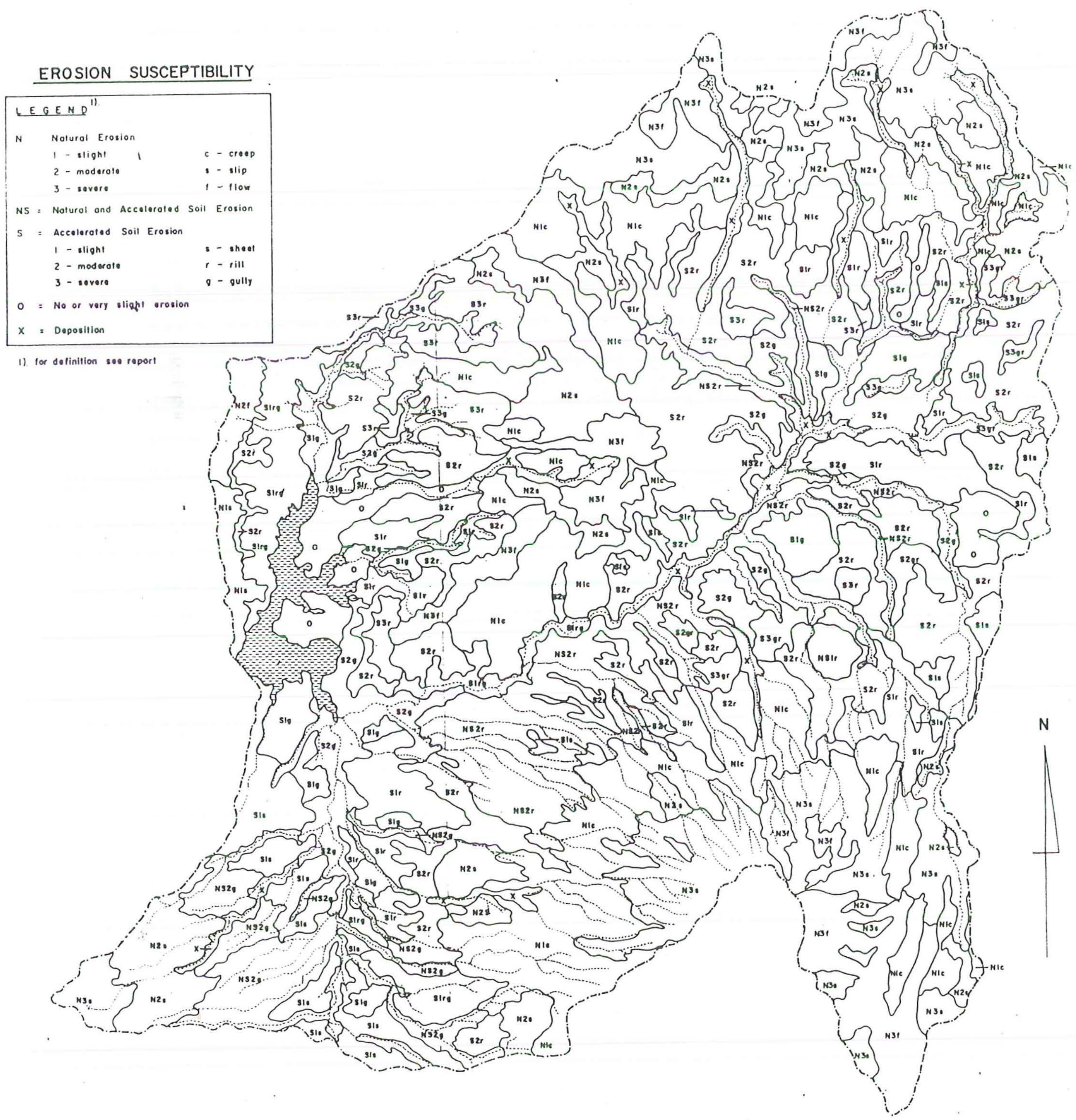

Fig. V.2. Generalized erosion susceptibility sketch map Kali Konto Watershed
(not to scale)
(reduction of the 1:50.000 actual erosion map)

A second zone is the "middle belt", the middle and lower slopes, foothills and footslopes of the volcanic complexes. Most of these slopes are stable and natural erosion is minimal. As most of these lands are found within the forest boundary, accelerated soil erosion, induced by man, is equally a minor problem.

A third zone concerns the agricultural areas. These areas are geomorphologically characterized by an active advancing river system cutting deep in the intervolcanic plain, particularly in the area of Pudjon. Natural erosion, as a result of headward and sideward gully formation, is considerable, partly accelerated by farming practices (critical areas). In the agricultural areas itself erosion is mostly in the form of rills and gullies. The tegallan lands on the foothills and footslopes are the most critical areas (rill and gully erosion, induced particularly by plowpan formation). In the irrigated areas, gully erosion varies depending on the general slope characteristics. On the steeper irrigated lands slumping (collapse of sawah systems) often is an additional problem. A major source of erosion and sediment yield in the Selorejo reservoir are the urbanized village areas and the dense network of farmroads and footpaths.

The erosion susceptibility map indicates the type and intensity of erosion to be expected under the same conditions of climate, soils and agricultural practices, but considering the present trends of an increasing population, a higher population pressure, smaller farms, continuation of the degradation of the forest resources, decreasing water resources and increased competition for the available water resources. The map is not based on the introduction of other types of land use or crops or considerable changes in management, and therefore the map is not an erosion hazard map.

V.3. SOIL EROSION RESEARCH

Runoff and Erosion from Run-off plots

In connection with the soil survey of the Kali Konto area, staff and students of Universitas Brawijaya and in cooperation with Proyek Brantas, have set up a small series of field experiments. The purpose of the experiments is to monitor and evaluate quantitatively run-off and erosion on different soils and under various soil and crop management systems (PSLH Unibraw, 1984).

The experiments are carried out on run-off plots of approximately 50 m^2 (16 x 3 m), closed on all sides to avoid soil and water from surrounding areas to enter the plots and with a set of collector's drums at the lower end.
The first experiments were set up on the steep Kali Konto valley-side slopes near Pudjon (soil mapping unit Ps/BC), on an 35% slope. The slope is terraced following the common practice of cut and fill and the runoff plots are laid down on the individual terraces to monitor run-off and erosion on terraced land. The slope within each terrace varied from 1-10%.
The purpose of the experiments was to monitor runoff and erosion from farmer's fields under various crop and soil management practices. The results show that erosion is limited and that the steep valley sides can be used provided the lands are extremely well terraced.

A second set of experiments is set up in the area of Jombok (Ngantang) on the intervolcanic plain (soil mapping unit Pl/NA) on a 3% slope. The area is not terraced. The various crop and soil management practices selected are in accordance with the local practices.
The first results, covering the rainy season of 1983/84, are presented in table V.1.

Table V.1. Runoff and Erosion from run-off plots during rainy season 1983/84

Site A: Pudjon
Landform : Erosion valley-sides (Ps)
general slope 35%; terraced land

Soilunit : Bendosari complex (BC); Dystric Cambisol

Treatment	slope within terrace	Runoff m^3/ha	Erosion kg/ha	CP
1. Bare soil	4 %	3.752	20.340	-
2. Cabbage	2 %	2.157	15.350	0.75
3. Maize	1 %	126	318	0.01
4. Maize on beds	1 %	74	274	0.01
5. Maize and carrots	1 %	282	912	0.04
6. Grass	1 %	145	304	0.01
7. Coffee	9 %	66	312	0.01

Site B: Ngantang (Jombok)
Landform : lower volcanic plain (Pl)
general slope 3%; non terraced land

Soilunit : Jombok series; Mollic Cambisol

Treatment	slope	Runoff m^3/ha	Erosion kg/ha	CP
1. Bare soil	3 %	3.984	17.780	-
2. Maize	3 %	2.356	7.048	0.40
3. Groundnut	3 %	1.950	5.040	0.28
4. Maize + Groundnut	3 %	1.481	2.730	0.15
5. Cassava	3 %	2.631	8.046	0.45
6. Maize + Cassava	3 %	1.872	4.438	0.25
7. Coffee	3 %	54	232	0.01

The Ngantang data indicate that for annual crops terracing of the very gently sloping lands remains a necessity.

Rainfall Erosivity Indices

Soil loss is closely related to rainfall through the detaching power of raindrops striking the soil surface and the contribution of rain to run off. The ability of rain to erode the soil is known as the erosivity of the rainfall. Rainfall erosivity is usually expressed as an index based on the kinetic energy of the rainstorms. It is, in turn, a function of its intensity and duration, both of which are determined by the number, mass, and velocity of the raindrops together with the frequency of occurrence. To compute the erosivity of a rainfall one requires data on the characteristics of rainfall. Such data are hardly found in the survey area. It is therefore that Utomo et.al. (1983) tried to calculate a rainfall erosivity index from monthly rainfall data which are available from many stations. They analyzed rainfall data obtained from eight automatic rain gauges installed in the area of Kali Brantas watershed. Then they related them to the monthly observations, and obtained the following equation :

$$R = 2.80 + 4.15 M$$

where : R is rainfall erosivity index
M is monthly rainfall (in cm)

Rainfall erosivity indices of five stations in Kali Konto area are calculated according to the equation, and the results are given in Table V.2. The erosivity indices obtained from the western part of the watershed (represented by stations in Ngantang, Selorejo and Sekar) are generally higher than from the eastern part (Pudjon and Kedungrejo). The monthly indices are high during the month of November to May, in all stations. The data indicate that the erosivity of the rainfall in the watershed can be classified as high, particularly from December to March.

Table V.2. Rain erosivity calculated from average monthly rainfall using the equation $R = 2.8 + 4.15 M$.

Station	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Pudjon	152	159	123	74	39	31	15	15	22	50	102	132	886
	162	150	131	67	51	23	23	16	20	51	94	130	888
Kedungrejo	153	174	128	75	53	28	11	12	23	36	81	124	866
	208	158	140	70	58	24	18	11	17	49	87	148	959
Ngantang	181	180	149	96	66	37	17	13	15	43	88	130	984
	211	174	166	91	68	25	23	18	19	53	83	152	1052
Sekar	212	183	177	112	77	32	22	14	15	46	111	166	1136
Selorejo	178	155	149	88	73	24	14	16	26	56	75	104	928

V.4. SUMMARY AND CONCLUSIONS

1. Erosion on the steep and very steep mountain slopes in the highest parts of the watershed is a natural process that cannot be stopped but that can be controlled through proper forest management and conservation practices.

2. The natural erosion in the highest parts of the watershed does not contribute directly to the large amounts of sediment deposited in the Selorejo reservoir.

3. Erosion is critical in many tegallan areas, particularly on the steeper slopes with slope gradients over 12%. Important additional factors appear to be the presence of plowpans, particularly in soils which are occasionally irrigated or which were irrigated in the past. Another factor are the bench terraces, which are often sloping or otherwise not correctly maintained, resulting in concentration of run-off water.
Erosion in the tegallan lands can be controlled, through adapted soil and crop management practices, well constructed level bench terraces or reverse-slope terraces, and gully control.

4. Erosion also occurs in the irrigated areas, in the form of gully erosion and due to the collapse of terraces (on slopes over 12%). Although gully erosion control is difficult and expensive, simple and temporary structures such as brushwood dams, brick weirs, etc. can be effective.

5. The existence of large agro-residential areas is an important factor in the occurrence of concentrated run-off water and subsequent gully erosion. Structures to disperse village run-off water and proper road drainage are essential to reduce the force and erosive power of the run-off water.

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SECTION VI. SOIL FERTILITY

VI.1. INTRODUCTION

The general fertility properties of the individual soil units recognized are described in Section III.
However, morphological similar soils still may show a wide range of nutritional values, laterally and vertically. The variability is due to both natural and cultural conditions such as:

a) natural conditions
- micro variability in the parent material, i.e. local variations in the composition of the volcanic deposits
- local variations in weathering, removal and redeposition of weathering products and nutrients
- biological factors such as variations in the soil fauna and natural vegetation.

b) cultural factors
- land use, different plot histories, etc.
- soil, crop and water management, including terracing and fertilization
- differential erosion and accretion; i.e. removal of soil material from the higher parts of individual plots and deposition in the lower parts.

As a result, the fertility status of individual soils and plots may vary considerably within each soil unit recognized on a soil map. Soil fertility is thus site-specific and situation-specific.

A soil fertility evaluation is the process by which nutritional problems are diagnosed and fertilizer use recommendations made. A soil fertility programme involves several steps. Soil fertility

has to do principally with plant nutrients and soil conditions and concerns levels of availability and nutrient balances in the soil. A soil survey, separating the major soil groups is only a first step. This should be followed by sampling of composite root zone soil samples of representative fields (representative in the sense of soil type and cultural factors such as land use, plot history and soil and plant management).
A next step is the correlation between the analytical data and crop responses. Usually, these correlations are conducted at two levels: an exploratory one in the greenhouse and a more definite on carefully selected farmer's fields.
This step requires research programmes extended and repeated over a number of years. The final step involves interpretation and recommendation and putting the information to use (agric. extension).

So far no soil fertility evaluation programme has been conducted in the area and it will be clear that such a programme is neither part of a soil survey.
Based on the results of the soil survey, however, the survey team collected and analyzed a large number of composite soil samples from representative soil types under representative soil, crop and land management practices. A composite sample is composed of approx. 20-30 subsamples from the rooting zone of a field. Non representative spots, such as plot borders, terrace borders, manure piles etc. were avoided. Sixty fields were sampled this way.

The analysis of the composite samples permitted the recognition of eleven (11) different zones, each with soils having fairly similar general fertility characteristics. (fig. VI.1a).

Comparing this sketch with the soil and landform map we see that the recognized "soil fertility zones" coincide with the broad soil and landform "provinces", as follows:

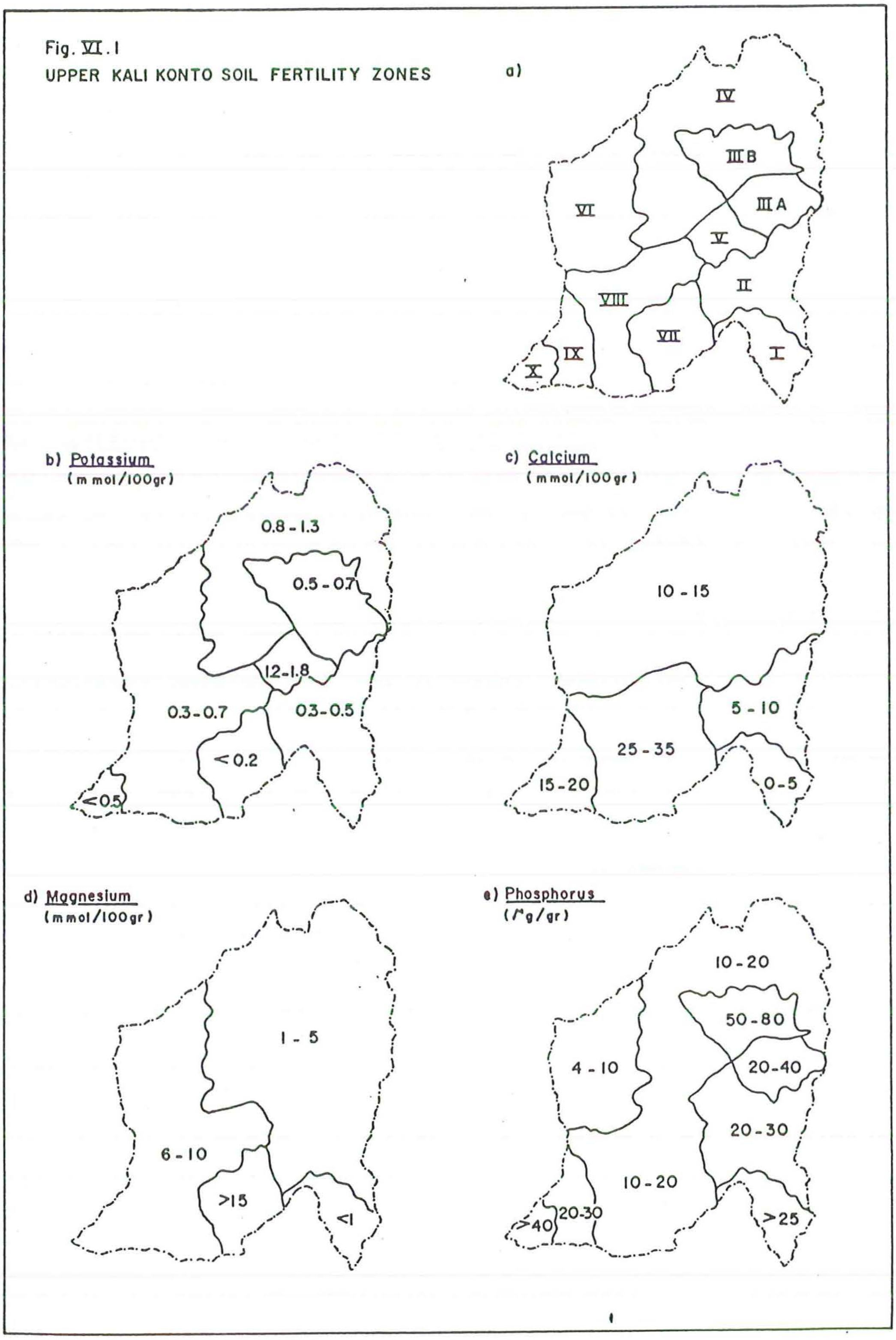


Fig. VI.1
UPPER KALI KONTO SOIL FERTILITY ZONES
a)
IV
IIIB
IIIA
VI
V
II
VIII
VII
I
IX
X
b) Potassium
(m mol/100gr)
0.8 - 1.3
0.5 - 0.7
1.2-1.8
0.3-0.7
0.3-0.5
<0.2
<0.5
c) Calcium
(m mol/100gr)
10 - 15
5 - 10
25 - 35
15-20
0-5
d) Magnesium
(m mol/100gr)
1 - 5
6 - 10
>15
<1
e) Phosphorus
(μg/gr)
10-20
50-80
20-40
4 - 10
20-30
10-20
>40
20-30
>25

Zone I	-	the northern upperslopes of the Kawi-Butak mountain complex soil unit : Gunung Butak series (GB)
Zone II	-	the northern middle slopes of the Kawi-Butak mountain complex soil unit : Coban Rondo series (C)
Zone IIIA	-	the Pudjon intervolcanic plain (southern section) and the adjacent footslopes of the Kawi mountain soil units: Pudjon series (P), Tawangsari series (T), Sebaluh series (B) and Kraantje Lek series (L).
Zone IIIB	-	the Pudjon intervolcanic plain (northern section) and the adjacent footslopes of the Anjasmoro mountain range soil units: Tawangsari series (T), Kraantje Lek series (L) and Sebaluh series (B)
Zone IV	-	the southern slopes and hill complex of the Anjasmoro range soil units: Ngebrong series (N)
Zone V	-	the northern footslopes of the Kawi mountain in the Bendosari area soil units: Kraantje Lek and Sebaluh associations (LB), some Tawangsari series (T)
Zone VI	-	the western slopes of the Anjasmoro range, the Luksongo hills and the Selorejo intervolcanic plain soil units: Ngantang-Jabon association (NA), Jombok series (J), Kaumrejo series (K) and the Selorejo series (S)
Zone VII	-	the western slopes of the Kawi mountain soil unit : Ngebrong series (N)
Zone VIII	-	the western footslopes of the Kawi mountain and the Kelud-Kawi intervolcanic plain soil units: Ngantang-Jabon association (NA), Kaumrejo series (K) and the Selorejo series (S)
Zone IX	-	the middle and footslopes of the Kelud soil units: Ngantru series (G) and the Gombong complex (GC)
Zone X	-	the upperslopes of the Kelud soil unit : Gunung Kelud complex.

Per zone and per individual nutrient (potassium, calcium, magnesium and phosphorus) the average concentration in the rooting zone, the subsoil and the complete profile were calculated. Extreme (low or high) values were replaced by data from adjacent horizons. The average data of the complete profiles were recorded on figures similar as fig. VI.1.a. Through the introduction of ranges of nutrient concentrations, some zones could be combined, resulting in a set of single value fertility sketchmaps (fig. VI.1.b-e). In the following paragraph the average root zone and subsoil values of the individual elements are used for a discussion of the fertility status per element. Nutritional imbalances, such as imbalances in the ratios of available calcium and magnesium and magnesium and potassium are discussed as well.

VI.2. THE LEVELS OF THE INDIVIDUAL PLANT NUTRITIONAL ELEMENTS

Nitrogen

In spite of the fact that most soils of the project area are rather well provided with organic matter (from 2-5% in most soils of the intervolcanic plains till over 15% in the soils of the highest mountain crests), readily available nitrogen is the nutrient element most frequently in short supply. With the exception of recently cleared land most cultivated soils are deficient in this element.

Determining the nitrogen requirements of the soils is difficult as most analytical laboratory determinations do not meet the criteria for a successful soil test.

For a particular soil type and under similar climatic and soil management conditions total soil nitrogen and organic matter are sometimes correlated with nitrogen response. Although the correlation may be good in greenhouse experiments in some cases, in the field the correlation is generally poor (Sanchez, 1976). Other analytical methods, such as incubation methods to evaluate nitrogen mineralization rates, are too time consuming and cumbersome for routine purposes.
Since there are thus no practical soil tests for estimating the available nitrogen levels in the soil, the determination of the nitrogen requirements has to be based on field experimentation.

Potassium

The 1 N. ammonium acetate extraction is usually considered to approach best the available forms of soil potassium. Critical levels for tropical soils separating adequacy and deficiency for many crops are as follows (Boyer, 1972, Sanchez, 1976)

$<$ 0.2	mmo/100 grs soil	- very low
0.2-0.4	- " -	- low
0.4-0.8	- " -	- moderate
0.8-1.5	- " -	- moderately high
$>$ 1.5	- " -	- high

The potassium levels of the soils of the "soil fertility zones" are indicated in fig. VI.1.b.

In the soils on the Kawi-Butak complex the available potassium levels are low to very low, but the nutrient is well distributed in both horizontal and vertical direction. Also the soils on the upper slopes of the Kelud are low in potassium. The deficiency on the Kelud is not only due to the average low values, but more so as a result of the extreme low values repeatedly found in some of the soil horizons. The low potassium values of the Kelud confirm the mineralogical data of the Kelud ashes (Baak, 1949). Substantial deposition of potassium poor material of the Kelud on the western (Kelud-facing) slopes of the Kawi could explain the very low potassium levels in zone VII. The higher potassium levels of zone I (northern slopes of the Butak-Kawi) may also be due to less leaching (rainshadow side of the mountain). The potassium levels in the soils of the other zones are moderate and even moderately high (zone IV). As the latter zone is a rain-facing area with intense leaching, the high potassium levels of the Anjasmoro mountain range can only be explained by assuming the soils are developed in parent material (ash) high in potassium bearing minerals.

On a meso scale, the potassium levels are higher in the soils of lower slopes and in drainage ways than in the soils higher on the slopes and on the crests. This could be caused by potassium being leached and laterally moved down the slopes.

Calcium

Like potassium, the available forms of calcium are well determined by the 1 N ammonium acetate extraction. The critical levels are as follows (Hauser 1974, Sanchez 1976):

$<$ 2	mmo/100 grs soil	-	low
2-10	- " -	-	moderate
$>$ 10	- " -	-	high

The calcium levels of the soils of the different "soil fertility zones" are indicated in fig. VI.1.c.

The soils on the upper Butak-Kawi slopes (zone I) are low to very low. Leaching in this area being limited (rainshadow), it is likely that the parent volcanic ashes in this area are low in calcium bearing minerals. The same applies to magnesium (see below). The soils of the Anjasmoro range (zone III) and of the intervolcanic plains (zones III, V and VI) occupy an intermediate position, while the soils close to the Gunung Kelud (zones VII - X) are moderately high or high in calcium. The influence of the Kelud ashes in these areas with considerable amounts of calcium-rich minerals is clearly demonstrated.

On the meso scale, the calcium levels generally increase slightly downslope, being highest in the drainage ways. Lateral removal of calcium could be the explanation. The effect of leaching is also demonstrated in the individual soil profiles: subsoils are generally higher in calcium than topsoils.

Magnesium

Available forms of soil magnesium are also determined by the 1 N ammonium acetate extraction. Critical levels for many crops in tropical soils were determined by Buol (1975), as follows:

<1	mmo/100 grs soil	- very low
1-3	- " -	- low
>3	- " -	- moderately high

The magnesium levels of the soils of the various "soil fertility zones" are indicated in fig. VI.1.d.

Generally speaking, the magnesium levels decrease with increasing distance from the Kelud volcano.
The soils of the Pudjon area are invariably low in magnesium and the soils of the higher slopes of the Butak-Kawi complex (zone I) even very low. The differences are likely due to variations in the mineralogical composition of the parent volcanic ashes.

On the Kelud, the magnesium levels are fairly uniform and do not vary as much from horizon to horizon and from site to site as is the case with potassium and calcium.

At the meso scale, there is no significant difference in the magnesium levels between the soils on the upper and middle slopes and the soils of the valley bottoms and lower slopes. Within each profile the differences between topsoil and subsoil are equally insignificant.

Phosphorus

After nitrogen, phosphorus is the most commonly limiting nutrient in tropical soils. Phosphorus dificiencies are particularly common in young volcanic ash soils, rich in allophane, which has a high capacity to retain or "fix" phosphorus. As the allophanic character of the volcanic soils of the area increases with altitude, also the phosphorus retention capacity increases with altitude (chapter II.5 and fig. II.7.c).

In these soils the main source of phosphorus for plants is organic phosphorus. The importance of maintaining soil organic matter is thus also a function of the maintenance of plant available phosphorus. As the organic matter contents are increasing in the cooler environments of the higher elevations, this aspect may compensate the higher fixing rates of the soils of these areas.

Several effective soil tests for estimating available phosphorus exists, the Bray extractions being the widest applicated in tropical volcanic areas. The tests however, are less suitable for flooded rice soils. The critical levels are (Buol, 1971):
(Bray II)

< 0.5	μ.g/gram soil	- very low
5-10	- " -	- low
10-30	- " -	- moderate
> 30	- " -	- high

The phosphorus levels of the soils of the various "soil fertility zones" are indicated in fig. VI.1.e.

The soils high in organic matter of the upper slopes of the Kelud and the Butak-Kawi are also fairly high in available (organic) phosphorus, inspite of the high P-retention capacities of these soils.
The high levels of zone IIIB can not be explained properly. The soils of zone VI (the northern part of the Ngantang intervolcanic plain) are lowest in available phosphorus; the soils of this area are also generally low in organic matter. In addition to the general trends, phosphorus deficiencies may particularly be expected in the intrigated lands, particularly on the Ngantang plain.

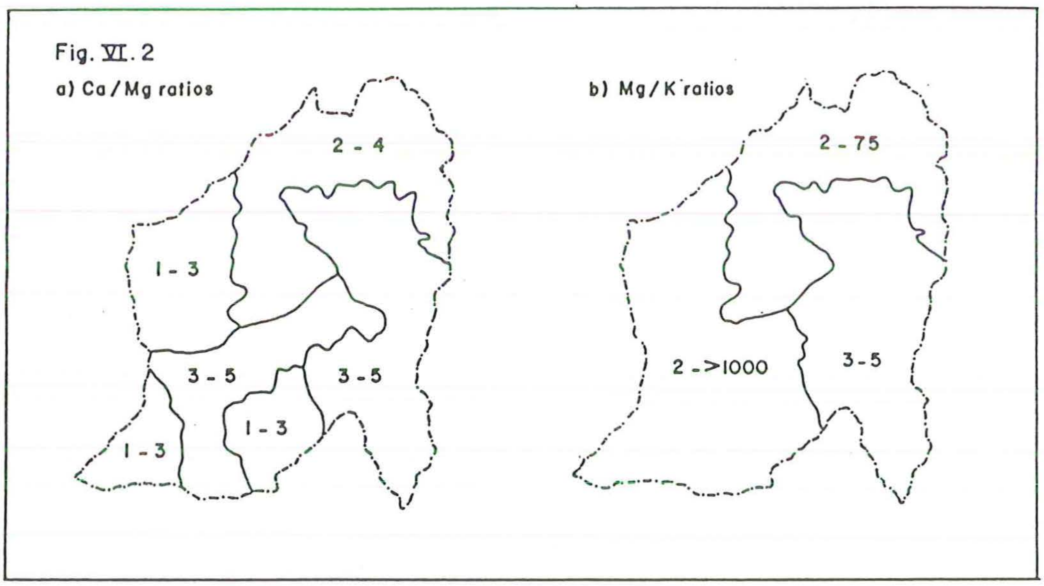
Nutrient imbalances

Nutrient deficiencies may also be caused by imbalances between the different elements. Some of the better known ratios, those of Ca/Mg and Mg/K were calculated for each analyzed horizon and were subsequently treated in a similar way as explained above for the individual elements.
The results are as follows (fig. VI.2):

Ca/Mg: optimum is approx. 2-3 (Buol, 1975).
In the Kali Konto area the ratios between plant available calcium and magnesium are rather well balanced and not in any part do they result in serious imbalances.

Mg/K: when $>$ 20-25, potassium is often deficient
when $<$ 3 , magnesium is often deficient
(Buol, 1975)
The Mg/K ratios vary enormously within the project area and imbalances can be expected in many areas. Only on the Pudjon plain and on the northern slopes of the Butak-Kawi mountain the ratios are generally within the optimum levels. On the Anjasmoro range and

in the Kelud area the ratio vary widely from 2-75 on the Anjasmoro to 2- > 1000 in the Kelud area. In the latter area the imbalance could lead to potassium deficiencies, particularly where the potassium levels are already low (fig. VI.1.b).



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SECTION VII. LAND SUITABILITY EVALUATION

VII.1. INTRODUCTION AND PURPOSE OF THE EVALUATION

This section concerns the interpretation of the collected land and soil resources data into terms of suitability.
Land suitability refers to the fitness of a given tract of land for a specific use and land evaluation is the process of assessing this suitability (FAO, 1976). The purpose of the land suitability evaluation is to provide a framework for the establishment of a management model for the lands of the Kali Konto Watershed and to avoid misuse and degradation of the land resources.

The Kali Konto Watershed is characterized by contrasting patterns of land use. The watershed includes agricultural areas ("village lands"), very densily populated and intensively used for a wide range of crops and cropping systems. The population pressure is high (or land is scarce), which is a major constraint for development. The remaining areas are forest lands, without population. Large tracts of these forest lands have important ecological functions, such as soil and water conservation. Other "forest" lands, however, are covered by an unproductive type of (kirinyu) vegetation.

In the agricultural areas, many generations of farmers have acquired ample experience on the agricultural potential of their land, their optimum use and management under the prevailing socio-economic and ecological conditions. In this situation, land evaluation can easily become an unneccessary, superfluous or even academic exercise.

However, large tracts of village lands are threathened by a shortage of irrigation water, while other areas are subject to severe erosion. The rapid siltation of the Selorejo Reservoir has alarmed the authorities. This situation asks for an evaluation of the management requirements of the agricultural lands, as a basis for proper soil and water conservation and land use planning. Land evaluation in the agricultural areas should thus indicate alternative forms of land use and/or management practices, aimed at restoring the ecological balance.

In the forest areas, the situation is different. Land evaluation in these areas is particularly needed for those areas which at present are "underused", or even without a productive type of vegetation (the scrub areas). Land evaluation should indicate if there are alternative forms of productive, protective and sustained land use, including suitable forms of (agro)-forestry and may be even agricultural production, without disturbing or damaging the precarious ecological balance of these areas.

Considering the above, the land suitability evaluation presented in this report has an ecological approach. It relates the specific ecological requirements of different land use alternatives with the ecological conditions of the different land units.

Different degrees of suitability depend upon the relationships between inputs (costs) and benefits (actual or anticipated). Although in the end "suitability" is a question of cost/benefit analysis, within the possibilities of sustained land use, economics did not enter the evaluation. The evaluation could also not be based on quantitative data such as production levels, crop yields, etc. The data required for such an approach were not, or only partly, available at the time of the evaluation, as land use in the agricultural areas is so much characterized by mixed cropping and relay cropping patterns.

Economic considerations are thus present only in the background, first in the selection of the land utilization types and second in the definition of the suitability classes.
On the other hand, the data provided by the ecological suitability evaluation presented in this report would serve as a basis for a subsequent quantitative economic evaluation, in which the results of the ecological evaluation would be subject to economic analysis.

VII.2. THE STRUCTURE OF THE LAND SUITABILITY CLASSIFICATION

The structure of the land suitability classification used is a system adopted in all studies and surveys carried out by the Soil Science Department of Universitas Brawijaya and which is also being used nationally.

According to this system, the suitability of a certain land unit is indicated following a classification consisting of three levels of detail :

Land Suitability Order
Land Suitability Class and
Land Suitability Subclass

a) Land Suitability Orders

Order S: SUITABLE LAND Lands on which sustained use of the kind under consideration is expected to yield benefits that will justify the required inputs without unacceptable risks of land degradation or other damage to the environment.

Order N: UNSUITABLE LAND Lands having characteristics which appear to preclude its sustained use of the kind under considera-tion or which would create production, upkeep and/or conservation problems, requiring a level of inputs unacceptable at the time of the interpretation.

b) Land Suitability Classes

Land suitability classes indicate the relative degree of suitability for the defined purpose in the defined manner. The classes are numbered in order of decreasing suitability (increasing limitations).

Class S1: HIGHLY SUITABLE LAND Lands having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits.
Major improvements are not necessary and management practices required to ensure sustained use without hazard to the land resources are relatively simple and within the usual package of management practices. Lands permitting high yields at relatively low costs.

Class S2: MODERATELY SUITABLE LAND Lands with limitations which in aggregate are moderate for sustained application of a given use; the limitations will reduce productivity or benefits and increase required inputs to an extent that the overall advantage to be gained from the use, although still attractive, will be significantly inferior to that expected under optimal conditions. Land permitting moderate yields at relatively low costs or high yields at relatively high costs.

Class S3: MARGINALLY SUITABLE LAND Lands with limitations which in aggregate are severe for sustained application of a given use and that will seriously reduce productivity or benefits, or cause serious erratic variations in productivity or benefits, or that require corrections or inputs that will be only marginally justified. Lands permitting only marginal yields in relation to the costs.

Class N1: PRESENTLY UNSUITABLE LAND Lands with limitations which may be surmountable in time but which cannot be corrected with existing knowledge at presently acceptable costs and which preclude the successful sustained application of a given use.

Class N2: PERMANENTLY UNSUITABLE LAND Lands having limitations which cannot be corrected and which are so severe as to preclude any possibility of successful sustained use of the land in a defined way.

c) Land Suitability Subclasses

Land suitability subclasses are divisions within classes, distinguished by the nature of the main limitation (s) which have determined their classification. The subclasses are indicated by lower case letters following the class symbol. The following subclass symbols are used in this study :

c = climatic limitations (temperature, low radiation, often expresses as altitude)

d = unfavourable drainage conditions (excess subsurface water)

e = erosion hazard

f = flooding hazard

s = adverse physical soil conditions (stoniness, rockiness, dense subsoils, etc)

t = adverse topography (not because of erosion)

w = permanent lack of irrigation water (only use for class N2)

VII.3. SELECTION AND DEFINITION OF LAND UTILIZATION TYPES

Since there is no absolute and generally applicable value of land, the concept of land suitability is meaningful only in relation to the use of land for a specific purpose and in a defined manner. For this purpose specific land utilization types have to be selected and defined in detail.

Agricultural Land Utilization Types

The identification and selection of land utilization types (LUT's) for the evaluation of the agricultural areas (the "village lands"), was done in cooperation with Proyek Kali Konto[1].

Agriculture in the area is extremely complex as there are an infinite number of cropping patterns, mixed cropping systems, both on irrigated sawahs and dry tegallan lands. The differences are the result of local practices, traditions, the availability of

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1) the cooperation with Mr. Waluyo Nibbering is particularly acknowledged

irrigation water, marketing aspects and others.
Evaluation of all these different systems would be difficult and unneccessary as for the purpose of land evaluation with an ecological bias, the systems can be grouped into a number of patterns or clusters.
The following Land Utilization Types have been defined and selected:

- wetland rice (two to three crops per year) IRR
- wetland rice based cropping systems
  subtype : wetland rice followed by vegetables IRV
  subtype : wetland rice followed by maize IRM
- irrigated vegetable based cropping systems
  subtype : without maize (vegetables only) IVV
  subtype : with maize (January - May) IVM
- rainfed food and vegetable cropping systems (tegallans)
  subtype : maize - maize (or maize - beans) TMM
  subtype : maize - vegetables TMV
  subtype : vegetables - maize TVM
  subtype : maize - tobacco TMT
- mixed coffee gardens (kebuns) K

A detailed description of these Land Utilization Types will be reported by the agronomic and soc.econ. sections of Proyek Kali Konto. All types are already practiced in the area.

Forest Land Utilization Types

Considering the purpose of the land evaluation in the forest areas, i.e. to develop functional and productive forest systems, particularly to replace the very degraded forests and scrub vegetation on the middle and lower slopes of the mountain complexes, the following Land Utilization Types have been selected and defined:

- plantation forest FP
- fuelwood plantations FF
- agroforestry systems
  subtype : incl. annual crops and/or fodder AFA
  subtype : incl. perennial crops AFP

A detailed description of the selected forest Land Utilization Types will be reported by the Forest Section of Proyek Kali Konto, in separate reports. Some of the types are already practiced in the area, other LUT's are new or are "improved" types.

VII.4. SPECIFICATIONS FOR THE EVALUATION

This chapter describes the physical requirements of the various land utilization types that have been considered in the evaluation.

The requirements are based on the optimal conditions of the major land or soil characteristics; this is followed by a sliding scale of increased limitations.

The selection of the requirements and the rating of the limitations is probably the most difficult part of land evaluation, as information on optimal growing conditions is often unavailable, or only known in a qualitative or vague form. In the case of the Kali Konto Watershed, the ratings are based on :

- observations in the area itself on the growth and performance of different crops in different environments
- farmer's experience and experience from rural extension agronomists
- experiences and research carried out elsewhere in similar environments. a.o. reported by LPT-Bogor
- (scarce) literature on crop ecology.

In the following tables the optimal conditions and degree of limitations are indicated for each Land Utilization Type considered.

Table VII.1.

SPECIFICATION FOR THE PHYSICAL EVALUATION OF THE KALI KONTO WATERSHED LANDS

FOR WETLAND RICE (TWO-THREE RICE CROPS/ANNUM) SYMBOL LUT: IRR

Assumption: Availability of irrigation water is not considered; assume there is enough water (see text)

LAND/ SOIL CHARACTERISTICS	OPTIMAL CONDITIONS	DEGREE OF LIMITATION: SLIGHT	MODERATE	SEVERE
ALTITUDE (temperature, sunshine)	< 400 m	< 750 m	< 900 m	> 900 m
TOPOGRAPHY				
- macrorelief	< 1 %	1 -3 %	3 - 8 %	> 8 %
- microrelief	no or slight terracing is required	> 40m wide terraces possible	> 15m wide terraces possible	any other
SOIL PHYSICAL POPERTIES				
- texture	fine clayey, clay loam	very fine clayey, fine loamy, fine silty	coarse loamy	any other
- turn around period (TAP) [1]	< 15 days	< 30 days	< 45 days	> 45 days
- boulders, stones (surface)	none	none/slight	slight/ moderate	moderate or more
- permeability top soil	< 0.5 cm/hour	< 2.0 cm/hour	< 6.5 cm/hour	> 6.5 cm/hour
- effective soil depth till rock or skeletal subsoil (groundwater below 75 cm)	> 75 cm	> 50 cm	> 25 cm	> 10 cm
SOIL DRAINAGE				
- natural drainage class	imperfect-poor	poor-very poor imperfect-mod.well	very poor mod.well- well	excessively drained
- flooding (flashfloods)	none	sometimes, occ. damage	frequent, sometimes damage	frequent, serious damage
- moisture stress	never	sometimes, light	stress 4x in 10 years	any other
SOIL FERTILITY				
- pH topsoil (water)	> 6.0	> 5.0	< 5.0	-
- character epipedon	mollic/umbric	umbric/ochric	ochric	-

1) the period necessary for a puddled, semi-dried out padisol to become suitable again for planting the next crop.

Table VII.2.

SPECIFICATIONS FOR THE PHYSICAL EVALUATION OF THE KALI KONTO WATERSHED LANDS

FOR WETLAND RICE-BASED CROPPING SYSTEMS

SYMBOL LUT's : IRV
IRM

IRV : wetland rice (mid-December-May ending)followed by vegetables (mid June-September ending)
IRM : wetland rice (mid-December-May ending)followed by maize (mid June-November), relay cropping.

Assumption : Evaluation is based on the assumption that sufficient irrigation water is available

LAND/ SOIL CHARACTERISTICS	OPTIMAL CONDITIONS	DEGREE OF LIMITATION SLIGHT	MODERATE	SEVERE
ALTITUDE (temperature,sunshine)	< 400 m	400-700 m	700-1000 m	> 1000 m
TOPOGRAPHY				
- macrorelief	1-3 %	3-5 %	5-12 %	> 12 %
- microrelief	slight terracing max.cut/fill=25cm	> 40 m terraces max.cut/fill=50 cm	>15 m terraces max.cut/fill=75cm	<15 m terraces any other
SOIL PHYSICAL PORPERTIES				
- texture of topsoil	(silty)clay loam or light clay	(sandy)clay,loam, silty loam	sandy loam-heavy clay	NA
- turn around period (TAP)[1]	< 15 days	< 30 days	< 45 days	> 45 days
- boulders/stones (surface)	none	slight	moderate	very bouldary/ stony
- effective soil depth till skeletal subsoil	> 50 cm (IRV) > 60 cm (IRM)	> 30 cm (IRV) > 45 cm (IRM)	> 20 cm (IRV) > 30 cm (IRM)	< 20 cm (IRV) < 30 cm (IRM)
SOIL FERTILITY PROPERTIES				
- PH topsoil (pH water)	> 6.0	> 5.0	< 5.0	NA
- character epipedon	mollic/umbric	umbric	ochric	NA
SOIL DRAINAGE				
- natural drainage class				
IRV	imperfect	mod. well	somewhat excc./	excessive/poor
IRM	imperfect/mod.well	imperfect/poor; well	poor; somewhat excessive	very poor/ excessive
- permeability subsoil	slow	mod.slow/moderate	very slow/ mod. rapid	rapid
- flooding (flashfloods)	none	rare;light damage	annual;light damage	annual;mod/severe damage

cont'd

1) the period necessary for a puddled, semi-dried out padisol to become suitable again for planting upland crops (aeration, structureal reaggregation, etc. with help of simple trad. soil tillage practices).

SPECIFICATIONS

FOR WETLAND RICE-BASED CROPPING SYSTEMS (cont'd)

IRV : wetland rice (mid December-May ending),followed by vegetables (mid June-September ending)
IRM : " " " " " " , " by maize (mid July - mid November)

LAND/ SOIL CHARACTERISTICS	OPTIMAL CONDITIONS	DEGREE OF LIMITATION SLIGHT	MODERATE	SEVERE
AVAILABLE SOIL WATER DRY SEASON				
IRV (vegetables) 00-40 cm	> 550 mm	> 450 mm	> 350 mm	< 350 mm 1)
IRM (maize) 00-80 cm	> 600 mm	> 500 mm	> 400 mm	< 400 mm

1) based on irish potatoes being the most water demanding vegetable crop
systems without potatoes : 50 mm. less.

SPECIFICATIONS FOR THE PHYSICAL EVALUATION OF THE KALI KONTO WATERSHED LANDS

FOR IRRIGATED VEGETABLE-BASED CROPPING SYSTEMS

SYMBOL LUT's : IVV
IVM

IVV : without maize as a sole crop; some maize may be grown mixed with vegetables(from July-November)
IVM : with maize (mid January - early May)

Assumption : Evaluation based on the assumption that sufficient irrigation water is available (not limited)

LAND/ SOIL CHARACTERISTICS	OPTIMAL CONDITIONS	DEGREE OF LIMITATION SLIGHT	MODERATE	SEVERE
ALTITUDE (temperature, sunshine)	> 1000 m	800-1000 m	< 800 m	NA
TOPOGRAPHY				
- macrorelief	1-5 %	5-12 %	12-20 %	> 20 %
- microrelief	> 10 m terraces max.cut/fill=25 cm	> 10 m. terraces max.cut/fill=50 cm	> 5 m terraces max.cut/fill=75 cm	<5 m terraces any other
SOIL PHYSICAL PROPERTIES				
- texture of topsoil	loam, clay loam sa.clay loam, si.clay loam	clay, silty clay sandy clay, silt loam	heavy clay, sandy loam	NA
- boulders/stones	none	slight, moderate	very bouldery/stony	NA
- effective soil depth till skeletal subsoil	> 50 cm (IVV) > 60 cm (IVM)	> 30 cm (IVV) > 45 cm (IVM)	< 30 cm (IVV) < 45 cm (IVM)	any other
SOIL FERTILITY PROPERTIES				
- pH topsoil (pH H_2O)	> 6.0	> 5.0	< 5.0	NA
- character epipedon	mollic/umbric	umbric	ochric	NA
SOIL DRAINAGE				
- natural drainage class	mod. well	well/imperfect	somewhat excess./ poor	very poor/ excessive
- permeability subsoil	mod.slow/ moderate	slow	very slow/mod. rapid	rapid
- flooding (flashfloods) and ponding	none	none	occasional; light damage	any other
AVAILABLE SOIL WATER DRY SEASON 1)				
- avail. water (mm) 00- 40 cm	> 550 mm	> 450 mm	> 350 mm	< 350 mm

1) based on irish potatoes, being the most water demanding vegetable crop

Table VII.4.

SPECIFICATIONS FOR THE PHYSICAL EVALUATION OF THE KALI KONTO WATERSHED LANDS

FOR RAINFED ANNUAL FOOD AND VEGETABLE CROPPING SYSTEMS (TEGALLANS)

SYMBOL LUT's: TMM, TMV, TVM, TMT

TMM : maize-based cropping systems (maize or beans (Nov-Feb); maize or beans (early March-July)
TVM : maize-vegetable systems (maize or beans (Nov-Feb); vegetables (Feb-June)
TMV : vegetable-maize systems (vegetables (Oct-Feb); maize or sweet potatoes (March-Aug)

Assumptions:
- All crops are grown on terraced land, (common practice)
- Manure is used
- Altitude will not be considered as all three subsystems are suitable for the range 600-1300 m as found in the area. However, individual vegetable crops are selected according to their temperature requirements (e.g. red onions below 8-900 meters).

LAND/ SOIL CHARACTERISTICS	OPTIMAL CONDITIONS	DEGREE OF LIMITATION SLIGHT	MODERATE	SEVERE
TOPOGRAPHY				
- slopes < 250 meter	0-5 %	5-8 %	8-15 %	> 15 %
- slopes > 250 meter	0-3 %	3-5 %	5-12 %	> 12 %
SOIL PHYSICAL PROPERTIES				
- texture of topsoil	clay loam	loam, clay, sa. clay loam	heavy clay, sa. loam	NA
- effective soil depth till stony or scoria layer	> 100 cm	60-100 cm	40-60 cm	< 40 cm
- stoniness (incl. boulder)	none	< 15% (volume)	15-40% (vol)	over 40% (vol)
SOIL FERTILITY PROPERTIES				
- pH topsoil	> 6.0	> 5.0	< 5.0	NA
- character epipedon	mollic/umbric	umbric	ochric	NA
SOIL DRAINAGE				
- natural drainage class[1)]	mod, well	well	somewhat excess.	excessive

1) alternative drainage (padisols) is not considered; the evaluation of padisols will be based on the drainage class which will result after using the land for the rainfed cropping systems ("restored natural drainage class")

SPECIFICATIONS

FOR RAINFED ANNUAL FOOD AND VEGETABLE CROPPING SYSTEMS (CONT'D)

LAND/ SOIL CHARACTERISTICS	OPTIMAL CONDITIONS	DEGREE OF LIMITATION SLIGHT	MODERATE	SEVERE
AVAILABLE SOIL WATER DURING DRY SEASON				
TMM:maize period:March-July	> 600 mm	> 500 mm	> 400 mm	< 400 mm
TVM:vegetables 1) period:Febr-June	> 500 mm	> 400 mm	> 300 mm	< 300 mm
TMV:maize/sweet potatoes period:April-August	> 550 mm	> 450 mm	> 350 mm	< 350 mm

1) excl. maize as relay crop; incl. maize: add. 100 mm

SPECIFICATIONS WHEN ALL CROPS ARE CULTIVATED WITH IMPROVED SOIL MANAGEMENT (SPECIFICALLY : WITH WELL CONSTRUCTED TERRACES)

TOPOGRAPHY				
- slopes < 250 m	0-5 %	5-12 %	12-20 %	> 20 %
- slopes > 250 m	0-5 %	5-8 %	8-15 %	> 15 %

ADDITIONAL SPECIFICATIONS FOR MAIZE-TOBACCO SYSTEM (TMT)

TMT : maize-tobacco (maize (Nov-Feb); tobacco (March-July)

ALTITUDE	<700 m	<850 m	>850 m	
Available water during growing season	>600	>500	<400	<400

Table VII.5.

SPECIFICATIONS FOR THE PHYSICAL EVALUATION OF THE KALI KONTO WATERSHED LANDS

FOR MIXED COFFEE GARDENS (KEBUN)

SYMBOL LUT : K

Assumptions: - land over 5% slope is terraced
- altitude is not considered; individual crops will be selected acc. to their temperature requirements; shade trees acc. to altitude (cloudiness)

LAND/ SOIL CHARACTERISTICS	OPTIMAL CONDITIONS	DEGREE OF LIMITATION		
		SLIGHT	MODERATE	SEVERE
TOPOGRAPHY				
- slopes < 250 m	0-8 %	8 - 20 %	20 - 30 %	>30 %
- slopes > 250 m	0-5 %	5 - 12 %	12 - 20 %	>20 %
SOIL PHYSICAL PROPERTIES				
- effect.soil depth till scoria/pumice	>125 cm	>100 cm	>50 cm	<50 cm
- stoniness/boulders	none	<25 %(vol)	25 - 60 %	>60 %
SOIL FERTILITY				
- character topsoil	mollic/umbric	umbric	ochric	N.A.
- pH at 50 cm	>6.0	>5.0	<5.0	N.A.
SOIL DRAINAGE				
- nat.drainage class	well	mod. well	somewh.excess.	poor/excess

Table VII.6.

SPECIFICATIONS FOR THE PHYSICAL EVALUATION OF THE KALI KONTO WATERSHED

FOR FOREST AND AGROFORESTRY LAND UTILIZATION TYPES 1)

SYMBOL LUT's : **FP**
FF
AFA
AFP

FP = Plantation forest
FF = Fuelwood plantations
AFA = Agroforestry, incl. annual crops and fodder
AFP = Agroforestry, incl. perennial crops (coffee)

LAND/ SOIL CHARACTERISTICS		OPTIMAL CONDITIONS	DEGREE OF LIMITATION: SLIGHT	MODERATE	SEVERE
TOPOGRAPHY (terraced land)					
convex slopes					
Plantation forest	FP	<20 %	<45 %	<75 %	>75 %
Fuelwood plantations	FF	<20 %	<30 %	<50 %	>50 %
Agroforestry	AFA	<15 %	<20 %	<30 %	>30 %
Agroforestry	AFP	<20 %	<30 %	<45 %	>45 %
straight or concave slopes					
Plantation forest	FP	<20 %	<30 %	<50 %	> 50 %
Fuelwood plantations	FF	<20 %	<30 %	<40 %	> 40 %
Agroforestry	AFA	<15 %	<20 %	<25 %	> 25 %
Agroforestry	AFP	<20 %	<30 %	<45 %	> 45 %
SOIL FERTILITY					
character epipedon	AFA	mollic	umbric	ochric	N.A.
	AFP	mollic	umbric	ochric	N.A.
EFFECT SOIL DEPTH					
(till pumice layers)	AFA	>75 cm	> 50 cm	>30 cm	<30 cm
	AFP	>125 cm	>100 cm	>50 cm	<50 cm

1) Data partly provided by RIN/PKK

VII.5. THE SUITABILITY ASSESSMENT

Once the land units have been mapped and the basic resource data collected for each unit, the land utilization types have been selected, their ecological requirements determined and the class limits for these requirements been set, the stage of actual land suitability assessment has arrived.

Ecological suitability assessment is made by comparison of the (ecological) requirements of each land utilization type with the (ecological) conditions of each land unit. "Matching" is a popular expression of this exercise.

In the tables of the previous paragraph (tables VII.1 - 6) the specifications for the evaluation of the lands for the selected land utilization types are indicated. The requirements are expressed in terms of individual land characteristics, such as soil texture, soil pH, relief (slope angle), altitude, etc. These single attributes can be measured and expressed quantitatively. The problem is, however, that the individual land characteristics do not act alone, as their interaction is equally important. A second difficulty is that the "weight" or importance of the individual limiting factors may vary. For these reasons, the FAO framework for land evaluation (FAO, 1976) proposed the concept of "land quality". A land quality is a complex attribute of land which acts in a distinct manner in its influence on the suitability of land for a specific kind of use (FAO, 1976). For example, erosion hazard is a land quality resulting from the interaction of many single land characteristics such as slope angle, slope length, soil texture, structure, structural stability, infiltration capacity and rainfall erosivity. Whereas the single land characteristics can be measured and expressed quantitatively, the land quality "erosion hazard" cannot.

Fortunately, some land qualities can be expressed properly by one single land characteristic. Altitude in meters above sealevel, for example, is a fairly good single parameter to express the land qualities of solar radiation and temperature regimes, at least in the poject area.

Land suitability assessment based on single land characteristics thus has the advantage of being more quantitative, but a handicap is that account should be taken of the various interactions of the single characteristics. This requires a good "feeling" of the type of interactions, and how these influence crop performance. On the other hand, land suitability assessment based on land qualities avoids the problem of the need to consider interactions (though true only to a certain extent), but many land qualities are difficult to measure quantitatively.

The procedure followed in the study of the Kali Konto Watershed actually is a combination of the two approaches. Where land qualities could be indicated using one single land characteristic or otherwise be expressed quantitatively this has been done so. Examples are altitude (already mentioned), available water expressed in mm., water available during the growing period of the crop, nutrient availability expressed in the single parameter of the character of the epipedon (mollic, umbric or ochric horizons) and the ability of the soil to regenerate after wetland rice cultivation (expressed as TAP, turn around period).
In other cases however, single parameters have been used such as slope gradient, permeability, natural drainage class, soil pH, etc.

Some "try outs" carried out by the survey team indicated that for a relatively small area as that of the Kali Konto Watershed, the approach, together with a reasonable good "feeling" of the weight of the individual factors and their interactions, provided a good basis for assessing land suitability.

The result of the assessment as carried out by the survey team is presented in tables VII.7 and 8.

Most land units have not been assessed for all land utilization types, as certain land uses are not relevant for certain areas. In that case the symbol NR, not relevant applies. For example, the irrigated agricultural lands have not been assessed for agro-forestry systems, as these lands will not be used that way; at least not in the present socio-economic context. Also the areas which at present are under a (natural) forest vegetation are not assessed for agricultural land utilization types as these areas should remain under forest (a preliminary assumption). From this it will be clear that "not relevant" not necessarily means "ecologically not suitable".

Finally, it should be mentioned that the lack of sufficient quantitative hydrological data is a handicap for the proper assessment of land suitability for irrigated land utilization types. It has been assumed that those areas which are irrigated at present also in the future will have sufficient irrigation water, although in some areas this may not be the case.

For the tegallan lands, however, the problem is more serious. Although the tegallan lands and also those areas which only ocassionally are or can be irrigated, are evaluated for irrigated land utilization types, the assessment had necessarily to be based on the assumption that sufficient irrigation water is available or can be made available. In these cases the evaluation had thus the character of a potential suitability assessment.

Table VII.7

LAND SUITABILITY EVALUATION

VALLEYS AND INTERVOLCANIC PLAINS

SOIL UNITS	LAND UTILIZATION TYPES													
	IRR	IRV	IRM	IVV	IVM	TMM	TMV	TVM	TMT	K	FP	FF	AFA	AFP
Au/KC	S3.cs	S2.cs	S2.cs	S1	S1	S2.s	S1	S1	S2.cs	S2.d	NR	NR	NR	NR
Ac/TC	N2.c	N2.c	N2.c	N1/S2.s	N1/S2.s	S1	S1	S1	S2.c	S2.f	S1	S1	S1	S1
Ac/PC	S1	S1	S1	S2.c	S2.c	S2.d	S2.c	S2.c	S3.d	S2.d	NR	NR	NR	NR
Al/SA	N2.c	N2.c	N2.c	N2.s*	N2.s*	N2.s*	N2.s*	N2.s*	N2.s	S3.sf	S2.s	S2.s	S3.s	S3.sf
Al/Ks	S2.st	S2.st	S2.st	S2.s	S2.s	S2.s	S2.s	S2.s	S2.cs	S2.s	NR	NR	NR	NR
Pu/L	N2.c	N2.c	N2.c	N1/S2.s	N1/S2.s	S2.s	S2.s	S2.s	S2.c	S1	S1	S1	S1	S1
Pm/P	N2.c	N1/S2.c	N1/S2.c	N1/S1	N1/S1	S1	S1	S1	S2.c	S1	NR	NR	NR	NR
Pm/T	N2.c	S2.c	S2.c	S1	S1	S2.d	S1	S1	S3.cs	S3.cs	NR	NR	NR	NR
Pm/T.e	N2.c	S2.ce	S2.ce	S2.e	S2.e	S2.ed	S2.e	S2.e	S3.cs	S3.cs	NR	NR	NR	NR
Pl/G	N1/S3.s	N1/S3.s	N1/S3.s	N1/S3.s	N1/S3.s	S3.s	S3.s	S3.s	S1	S1	S1	S1	S1	S1
Pl/NA	N1/S2.t	N1/S1	N1/S1	N1/S2.c	N1/S2.c	S1	S1	S2.c	S1	S1	S1	S1	S1	S1
Pl/S	S1	S1	S1	S2.c	S2.c	S1	S2.c	S2.c	S3.sd	S3.sd	NR	NR	NR	NR
Pl/S.e	S3.et	S2.e	S2.e	S2.ec	S2.ec	S2.e	S2.ce	S2.ce	S3.se	S3.se	NR	NR	NR	NR
Ps/BC	N2.ts	N2.ts	N2.ts	N2.ts	N2.ts	N2.te	N2.te	N2.te	N2.te	N1/S2e	S2.t	S3.te	N2.te	S2.te
Pe/BR	N2.ts	N2.ts	N2.ts	N2.ts	N2.ts	N2.ts	N2.ts	N2.ts	N2.ts	N2.ts*	N2.ts*	N2.ts	N2.ts	N2.ts
Pd/Bl	N2.ts	N2.ts	N2.ts	N2.ts	N2.ts	N2.te	N2.te	N2.te	N2.te	N1/S2.e	S1	S3.t	N2.te	S2.t
Pv/IC	N2.ts	N2.ts	N2.ts	N2.ts	N2.ts	N2.te	N2.te	N2.te	N2.te	N1/S2.e	S3.t	S3.te	N2.te	S2.te

NR = Not Relevant

* = small parts of the unit may be suitable

Table VII.8

LAND SUITABILITY EVALUATION

HILLY LANDFORMS

SOIL UNITS	LAND UTILIZATION TYPES													
	IRR	IRV	IRM	IVV	IVM	TMM	TMV	TVM	TMT	K	FP	FF	AFA	AFP
Hc/B	N2.c	N1/S3.c	N1/S3.c	N1/S1	N1/S1	S2.e	S2.e	S2.e	S3.ce	S2.c	NR	NR	S1	S1
Hc/Bet	N2.ce	N1/S3.c	N1/s3.c	N1/S2.e	N1/S2.e	S3.e	S3.e	S3.e	N2.ce	S2.c	S1	S1	S2.e	S1
Hc/Ct	NR	NR	NR	NR	NR	S3.e	S3.e	S3.e	N2.ce	S2.t	S1	S1	S1	S1
Hc/GA	NR	NR	NR	NR	NR	N2.s	N2.s	N2.s	S3.s	S3.s	S1	S1	N1.s	S3.s
Hc/GC	NR	NR	NR	NR	NR	N2.st	N2.st	N2.st	N2.st	N2.st	S2.s	S2.s	N2.s	N2.s
Hc/Kt	N1/S2.t	N1/S2.t	N1/S2.t	N1/S2.c	N1/S2.c	S2.e	S2.e	S2.e	S2.e	S1	NR	NR	S1	S1
Hc/N	N2.w	N2.w	N2.w	N2.w	N2.w	S3.e	S3.e	S3.e	S3.e	S2.t	S1	S1	S1	S1
Hc/St	S2.et	S2.e	S2.e	S2.ec	S2.ec	S2.e	S2.e	S2.ce	S3.sd	S2.sd	NR	NR	NR	NR
Hi/Bet	N2.w	N2.w	N2.w	N2.w	N2.w	N2.e	N2.e	N2.e	N2.e	S3.c	S1.t	S2.t	S2.t	S2.t
Hi/KA	N2.w	N2.w	N2.w	N2.w	N2.w	N2.se	N2.se	N2.se	N2.se	N2.st	S2.st	S2.st	N2.st	N2.st
Hp/C	N2.w	N2.w	N2.w	N2.w	N2.w	S2.e	S2.e	S2.e	S3.ce	S1	S1	S1	S1	S1
Hp/N	N2.w	N2.w	N2.w	N2.w	N2.w	S2.e	S2.e	S2.e	S3.ce	S1	S1	S1	S1	S1
Hs/C	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	S2.t	NR	NR	NR
Hs/Cet	NR	NR	NR	NR	NR	N2.et	N2.et	N2.et	N2.et	N2.et	S2.t	S3.t	N2.te	S3.t
Hs/C.t	NR	NR	NR	NR	NR	N2.te	N2.te	N2.te	N2.te	S3.te	S2.t	S2.t	S3.t	S2.t
Hs/J	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	S2.t	NR	NR	NR
Hs/Jet	NR	NR	NR	NR	NR	N2.et	N2.et	N2.et	N2.et	N2.et	S2.t	S3.t	N2.te	S3.t
Hs/Jt	NR	NR	NR	NR	NR	N2.te	N2.te	N2.te	N2.te	S3.te	S2.t	S2.t	S3.t	S2.t
Hs/JSe	N1.te	N1.et	N1.et	N1.et	N1.et	N1.et	N1.et	N1.et	N1.et	S3.ts	S2.t	S2.t	S3.t	S2.t
Hs/LU	NR	NR	NR	NR	NR	NR	NR	NR	NR	N2.te	S3.te	N2.te	N2.et	N2.et
Hs/N	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	S2.t	NR	NR	NR
Hs/Ne	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	S3.te	NR	NR	NR
Hs/N.et	NR	NR	NR	NR	NR	N2.et	N2.et	N2.et	N2.et	N2.et	S2.t	S3.t	N2.te	S3.t
Hs/NEt	NR	NR	NR	NR	NR	N2.et	N2.et	N2.et	N2.et	N2.et	S3.et	N2.et	N2.et	N2.et
Hs/Nt	NR	NR	NR	NR	NR	N2.te	N2.te	N2.te	N2.te	S3.te	S2.t	S2.t	S3.t	S2.t
Hs/SS	NR	NR	NR	NR	NR	N2.et	N2.et	N2.et	N2.et	N2.et	N2.et	N2.et	N2.et	N2.et

VII.6. LAND SUITABILITY OF THE IRRIGATED VILLAGE LANDS

All irrigated areas in the Upper Kali Konto Watershed are characterized by terraced land and soils which are strongly modified by puddling and other practices of wet-tillage, resulting in the formation of soils with a typical "padisol" or "anthraquic" character (Section IV).

Most of the irrigated lands are under cultivation already for very long periods and generations of farmers have, through trial and error, developed cropping systems most suitable to the ecological conditions of their lands. On the Ngantang plains most of the cropping systems are rice-based, but in the Pudjon area above 850 m. a.s.l., where rice is a less suitable crop, irrigated vegetable-based cropping systems are the rule. Land suitability in the irrigated areas is thus particularly a function of altitude (temperature, cloudiness and solar radiation levels) and the availability of irrigation water, much more than particular soil conditions (tables VII.7.-8).

As indicated already, the availability of irrigation water has not played a role in the evaluation, as quantitative hydrological data were not available at the time of the assessment. It has been assumed that sufficient irrigation water is and remains avialble. As this availability in the future is by no means sure, the suitability of the lands for dry-land land utilization types has been assessed.

IRRIGATED LANDS - PUDJON AREA

mapping units:
Pm/T (741 ha); Pm/Te (315 ha); Au/KC (126 ha)

present major land utilization types:
vegetable based cropping systems IVM, IVV

major limitations:
Pm/T: some rill and gully erosion between fields
Pm/Te: gully erosion between fields; collapse of terraces after heavy rains on slopes over 12%
Au/KC: stones and boulders, on the land's surface

required special management practices:
general : improved water management (water economy) and spraying techniques (pest and disease control); development of adapted varieties and optimum fertilization practices (research).
Pm/Te: gully erosion control; devices to control excess runoff after heavy rains along roadbanks and in residential village areas.
Au/KC: removal of stones and boulders; locally some streambank erosion control.

relevant alternative land use systems:
rainfed vegetable-based cropping systems, fodder crops (with/without irrigation) are relevant and suitable alternatives. The lands are less suitable for rice-based cropping systems (temperature) and are marginally suitable for tree- and fruitcrops; agroforestry and fuelwood crops would underuse the land's potential. Au/KC: suitable for pekarangan systems and highly suitable for floriculture, ornamental plant nurseries and recreational facilities (the main road Malang-Kediri crosses the unit).

IRRIGATED LANDS - NGANTANG AREA

mapping units:
Pl/S (587 ha); Pl/Se (274 ha); Hc/St (176 ha); Hs/JSe (146 ha); Ac/PC (298 ha)

present major land utilization types:
wetland rice and rice-based cropping systems
IRR, IRV, IRM

major limitations:
Pl/S and Ac/PC: -
Pl/Se; Hc/St; Hs/JSe: gully erosion between fields and collapse of terraces after heavy rains on slopes of approx.> 12%.

required special management practices:

general: improved water management (water economy) and spraying techniques; development of adapted varieties and optimum fertilization practices (research).

Ac/PC: locally some streambank erosion control

Pl/Se and Hc/St: gully erosion control; devices to control excess runoff after heavy rains, particularly along roadbanks and in residential village areas

Hs/JSe: unit is presently unsuitable (N1) for irrigated and non-irrigated cropping systems (too steep), land use should be changed into mixed perennial crop gardens, other pekarangan systems or agroforestry systems; development of proper land utilization types for these steep areas is essential (research).

relevant alternative land use systems:

except for unit Hs/JSe, rainfed foodcrop systems (TMM) are suitable alternatives; the lands are less suitable for vegetable-based cropping systems (climate), but suitable for foddercrops (grass, maize). The lands are less suitable for perennial tree and fruitcrops, and agroforestry and fuelwood systems would underuse the land's potential. However, the latter systems offer good possibilities for the steep lands of unit Hs/JSe.

VII.7. LAND SUITABILITY OF THE DRY-LAND VILLAGE LANDS

Large tracts of the agricultural village lands do not have a continuous or sufficient irrigation water supply and are not, or only occasionally irrigated. Also for these areas, farmers have developed many different cropping systems suitable to the ecological conditions of their lands. At the higher elevations (the area of Pudjon), most dry-land cropping systems are based on vegetables grown in the wet season and during the periods just before and just after the heavy rains. Maize and other palawija crops are cultivated in the dry season (see also chapter I.4).

At the lower elevations (the area of Ngantang) mixed perennial crop and coffee gardens are typical (chapter I.4). Maize is the dominant annual rainfed crop, often intercropped with cassava. A particular cropping system is found on the lower slopes of the Kelud: a tobacco-maize rotation with perennial tree crops on the field borders (TMT).

Lack of irrigation water is the main limiting factor for the tegallans, as farmers would convert many tegallans into irrigated land if suffi - cient water becomes available.
Although some tegallans can never be irrigated, due to their topographic position, for many other tegallans the situation is different. A better use of the available water resources, improved water management as well as a good watershed management plan could result in a situation that some tegallans can indeed be converted into irrigated land.

In the present situation, most tegallans are thus unsuitable for irrigated land utilization types (class N1, presently unsuitable) and some permanently unsuitable (N2). However, this may change in the future and it is therefore that the tegallan land mapping units which are presently unsuitable (N1), have also be evaluated for the irrigated land utilization types, assuming that in the future irrigation water may become available (tables VII.7 - 8). As water resource data are still extremely scarce, it is at this stage impossible to say which areas may be converted in irrigated land. The assessment bears thus the character of a potential suitability.

<u>TEGALLANS OF THE INTERVOLCANIC PLAINS</u>

mapping units:
Pu/L (387 ha) and Pm/P (659 ha) on the Pudjon plain
Pl/NA (1.219 ha) and Pl/G (497 ha) on the Ngantang plain

present major land utilization types:
Pu/L and Pm/P: vegetable based cropping systems (TVM, TMV)
Pl/Na: mixed perennial and coffee gardens and foodcrop based cropping systems (K, TMM)

Pl/G: maize-tobacco rotation and mixed coffee gardens (TMT, K).

major limitations:

Pu/L and Pm/P: some slight rill erosion; low waterholding capacity (Pu/L)

Pl/NA: locally some slight rill erosion

Pl/G: low waterholding capacity

required special management practices:

general: proper terracing (bench terraces); tillage practices to prevent and break traffic pans; selection of adapted varieties and development of optimum fertilizer recommendations (research)

Pu/L: selection of low water demanding dry season crops

Pl/G: adapted rotations and selection of varieties to meet the particular soil conditions (research).

relevant alternative land use systems:

general: provided irrigation water is available, irrigated land use systems are recommended, particularly on Pl/NA and Pm/P; less so for Pu/L and Pl/G (higher infiltration rates). The lands are also very suitable for fodder crops (grass and maize). Units Pu/L and Pm/P are less suitable for perennial fruit- and tree crops (climate); also Pl/G is less suitable for perennials (too much damage in case of Kelud eruptions).

All lands are suitable for agroforestry and fuelwood, but the systems would probably underuse the land's potentials.

TEGALLANS OF THE FOOTHILLS AND HILLSLOPES

mapping units:

Hc/B (233 ha); Hc/Bet (118 ha); Hi/Bet (43 ha) (Sebaluh series in the Pudjon area; total 394 ha)

Hc/Kt (Kaumredjo series in the Ngantang area: total 1.149 ha)

very small parts of units Hp/C and Hp/N (Pudjon area only)

present major land utilization types:

Hc/B; Hc/Bet; Hi/Bet: vegetable and foodcrop based systems (TVM and TMV)

Hc/Kt: mixed perennial and coffee gardens and foodcrop based cropping systems (K, TMM)

major limitations:

susceptibility to rill and gully erosion, particularly in units Hc/Bet, Hi/Bet and Hc/kt.

required special management practices:

general: very careful soil and crop management practices; proper constructed and maintained bench terraces are essential; tillage practices to break traffic pans; selection of adapted varieties and development of optimum fertilizer recommendations (research)

Hc/B, Hc/Bet and Hi/Bet: development of more suitable cropping systems based on perennial crops (research); particularly unit Hi/Bet should no longer be used for dryland annual cropping systems (erosion)

relevant alternative land use systems:

general: the suitability for irrigated land use systems, provided sufficient irrigation water can be made available, is good for land with slope gradients up to 8%; suitability on steeper land is limited (collapse of terraces, gully erosion and size of the individual fields becomes limited). Units Hp/C and Hp/N are permanently unsuitable for irrigated land use hill plateaux.

Lands with slopes up to 15% are also suitable for fodder crops (grass in particular), but proper soil conservation practices remain important.

Lands are suitable for agroforestry, bamboo and fuelwood plantations, particularly on slopes over 12%, where alternative land use systems are limited or impossible.

TEGALLANS OF THE SMALL ALLUVIAL AND LAHAR VALLEYS

mapping units:

parts of units Ac/TC; Al/SA and Al/Ks; total area approx. 300 ha; other parts are within the forest boundary

present major land utilization types:

rainfed foodcrop or vegetable-based cropping systems (TMM, TMV and TVM); locally some agroforestry (AFA) or mixed perennial crop or coffee gardens (K)

major limitations:

variability in the soil conditions, stoniness (Al/SA), low water-holding capacities (locally); some risk of flooding (locally) and/or colluviation from adjacent slopes

required special management practices:

very dependent on local soil conditions (site specific); where soil conditions are good no special management required; where soil conditions are limiting adapted land use should be considered (e.g. agroforestry, forestry, etc.).

In many locations proper soil and water management practices such as streambank conservation, silttraps, etc. are recommended.

relevant alternative land use systems:
in (small) areas with good soil conditions (Al/TC), irrigated land use systems could be considered, as well as the development of perennial crop gardens; areas with droughty and stony soil conditions (Al/SA) could be used for agroforestry systems and fuelwood plantations; bamboo is locally a very suitable crop.

VII.8. LAND SUITABILITY OF THE FOREST LANDS

As indicated already earlier in this report, the forest lands can be subdivided into the following areas:

- the forest lands of the very steep erosion valleys, situated close or within the village lands
- the forest lands of the hillslopes with scrub vegetation
- the forest lands of the hill and mountain slopes with a forest vegetation.

THE FOREST LANDS OF THE EROSION VALLEYS

These lands concern the steep and very steep plateau and valley sides of many of the tributaries of the Kali Konto river system, which deeply cut into the intervolcanic plains. Particularly in the Pudjon area, the units cover extensive surfaces and through active gully systems, erosion is still advancing. The lands are the result of natural erosion, aggravated by man (erosion units NS). See also chapter II.4. units Ps and Pd (p.56).

The suitability of these lands for agricultural production is very limited. In addition to the steep relief, the soils are eroded, have shallow topsoils and are often droughty (Bendosari complex, p.88). Moreover, the establishment of a forest vegetation often failed, due to conflicting interests between the forester wanting to establish plantation forests and the local population looking for fuelwood not far from their homes. As a result, many of these lands are only covered by an unproductive kirinyu vegetation, although this vegetation appears to be effective as a means of soil conservation (dense root systems).

The suitability of the land for various land use systems are indicated in table VII.7 (units Ps, Pd, Pe, and Pv), and is summarized below:

mapping units:
Ps/BC (211 ha); Pe/BR (43 ha); Pd/BL (651 ha) and Pv/IC (333 ha). Total area : 1.238 ha approx.

present land utilization:
most lands are under kirinyu vegetation

major limitations:
excessive relief (25-75%), erosion hazard, shallow topsoils resulting in soils which dry out quickly

relevant land utilization alternatives:
situated not far from the villages, the lands offer good possibilities for some well managed agroforestry systems based on perennial crops, or based on perennial crops in combination with foddercrops (grass); agroforestry systems including annual foodcrops are not suitable. Also certain fuelwood species offer good possibilities, particularly species which rapidly develop a dense root system and prevent erosion. An extremely careful soil management, including well constructed bench terraces, are essential, particularly during the establishment period of the crops.
The lands also offer possibilities for pekarangan systems but these need to be developed and adapted to local conditions first (research); arabica coffee could be a promising perennial for such systems.
The lands are permanently unsuitable for irrigated land utilization types (too steep, high infiltration rates), even if irrigation water is available. An exception are those areas with slopes less than 30-40%.
Land unit BR should be kept permanently under natural vegetation; the unit is characterized by an attractive scenery of waterfalls and the lands of the valley below (Au/KC) could be developed

as recreational areas.
Land unit Pd/BL is situated farther away from residential village lands and plantation forests have a better chance.

THE FOREST LANDS OF THE HILLSLOPES WITH SCRUB VEGETATION

The scrub areas of the hillslopes actually form an intermediate belt between the agricultural lands of the intervolcanic plains and foothills and the forest areas of the highest mountainous complexes (see also fig. I.2). The scrub belt covers a total area of approximately 6250 ha. Many of the lands are somewhat terraced and many are slightly or moderately eroded. Severe erosion in this belt is rare. The soil conditions vary, but nearly all soils are loamy, young volcanic ash soils (see chapter II.5, p.61). An exception are the soils of the Gunung Kelud which are formed in alternating layers of volcanic ash and pumice gravels.

The purpose of land evaluation of these areas is to assess the ecological suitability of the various land units for alternative land use systems, which may replace the present unproductive kirinyu vegetation, without disturbing the ecological balance. Particularly agroforestry systems have been considered but also dryland agricultural land utilization types. Irrigated land utilization types are not considered, as it is felt that even if irrigation water is available, this could better be used to irrigate the tegallan lands of the village areas. Moreover, irrigation of the Andosols would require high amounts of water as the infiltration capacity of the soils is very high, particularly during the first years of irrigation.

mapping units:

most units:

Hc/Ct	: 72 ha	Hs/Jt :	149 ha
Hs/Cet	: 362 ha	Hs/Net:	1.286 ha
Hs/Ct	: 66 ha	Hs/NEt:	72 ha
Hs/Jet	: 789 ha	Hs/Net:	4.056 ha

and parts of units:

Hc/GA	:	161 ha	Hp/N	:	304 ha
Hc/GC	:	353 ha	Hp/C	:	291 ha
Hs/LU	:	255 ha			

major limitations:
excess relief, more than erosion hazard; low levels of incoming solar radiation (cloudiness, mist)

relevant land utilization alternatives:
The possibilities for annual food or vegetable-based cropping systems are very limited. Only the small hill plateaux and crests (Hp/C and Hp/N) are suitable for these land utilization types, but many of these units are found far away and cover small areas which does not justifies their use. Also the colluvial footslopes, just within the forest boundary are (marginally) suitable, but these areas cover very limited surfaces (unit Hc/Ct: 72 ha). The sloping parts of unit GA on the Kelud, also just within the forest boundary and with slope gradients not exceeding 15% offer very marginal possibilities for tobacco-maize based cropping system TMT.
The uneroded hillslopes with slope gradients not exceeding 40-45% (parts of units Hs/Ct, Hs/Jt and Hs/Nt) are marginally suitable for perennial mixed cropping systems, for example based on arabica coffee, but research will be necessary to establish the most suitable system and the necessary crop and soil management practices.
Betters suited land use alternatives are plantation forests, fuelwood plantations and some agroforestry systems based on perennial crops. The non-eroded lands with slope gradients not exceeding 45% are generally suitable for these land use alternatives; the slightly-eroded lands marginally suitable. All areas with slope gradients over 45% are generally unsuitable for agroforestry and fuelwood land use systems and are marginally suitable for plantation forest systems. For details see table VII.8.

THE FOREST LANDS OF THE HILLY AND MOUNTAINOUS LANDFORMS WITH A (NATURAL) FOREST VEGETATION

These areas have not been evaluated as the lands should remain under a forest cover. Some forests should remain strict protection forests, natural soil and water conservation forests, while other forests may offer possibilities as a natural production forest. However, these considerations are mainly the concern of the forest specialists. It is hoped that the data on landform, soil and erosion conditions of these areas, as presented in this report, will assist the foresters in his planning of the natural forests.

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APPENDIX

MORPHOLOGICAL DESCRIPTIONS AND ANALYTICAL DATA OF REPRESENTATIVE PROFILES.

This annex concerns the morphological descriptions and tables of laboratory data of pedons of the major soil units recognised. The profiles represent examples of representative and typifying profiles.

1. SOIL DESCRIPTIONS

The soils are described according to:

a) Soil Survey Manual. US Department of Agriculture. Handbook 18. 1951 and 1962 supplement.

b) Guidelines for Soil Description. FAO Land and Water Development Division, FAO Rome, 1967.

c) The soil structure and macroporosity are described according to an adapted field method: G.W.van Barneveld, 1969. Description of soil structure and macroporosity in the field. Actas 5a Reunion Ciencia del Suelo, Santa Fé, Argentina.

d) The Soil Survey Manual is presently under revision. The new Manual will include new designations for soil horizons and layers. The new designations have been added in brackets.

2. SOIL CLASSIFICATION

The soils are classified according to the three soil classification systems presently in use in Indonesia: the Indonesian soil classification system (in development), the FAO/UNESCO Legend of the Soil Map of the World and in the US Soil Taxonomy. The following literature refers:

a) Kunci Penetapan Jenis dan Macam Tanah. BPT-Bogor 1981.

b) FAO/UNESCO 1974. Soil Map of the World. Volume I. Legend

c) Soil Taxonomy. A basic system of Soil Classification for Making and Interpreting Soil Surveys. Soil Conservation Service USDA Agric. Handbook 436. 1975

The Indonesian and FAO/UNESCO legends are particularly designed for exploratory and broad reconnaissance soil maps. They lack sufficient detail for use in detailed soil surveys. In the Kali Konto survey new units and subunits were recognized and introduced. These new proposed taxa carry an asterix *.

3. LABORATORY METHODS AND PROCEDURES

The laboratory methods and procedures used are basically those in current use in international standard soil laboratories.

The samples were analysed in the laboratories of the Soil Science Department of Unibraw in Malang. However, the analysis of the soil extracts for the determination of Ca, Mg, K and Na of profiles KK1 - KK15 were carried out on the Atomic Absorption Spectrophotometer of the Sugar Research Institute at Pasuruan.

Collected samples were air-dried, crushed in a mortar and passed through a 2 mm sieve. Determinations were performed on the fine earth fraction (< 2 mm) and results are reported on that basis.

a) Particle size analysis: USDA standard sieves (to determine the sand fractions) and the pipette method(determination of clay and silt fractions) after destruction of the organic matter (H_2O_2) and using sodium hexametaphosphate as dispersing agent. Andosols and other soils developed in volcanic ash generally do not disperse well and in that case particle size analysis is a meaningless exercise. For this particular group of soils the field estimates on handfeeling are more precise and reliable.

b) Organic Carbon: Walkley and Black, wet acid-dichromate digestion and $FeSo_4$ titration.

c) Total Nitrogen: Semi-micro Kjeldahl digestion followed by ammonium destillation and titration with sulphuric acid.

d) pH (H_2O and KCl): Potentiometrically using a combined glass-calomel electrode in a 1:1 ratio of soil and respectively H_2O and M KCl.

e) Exchangeable cations: Displacement with 1 M NH_4OAc at pH 7,0 and determination of Ca, K and Na by flamephotometry and Ca + Mg by EDTA titration (Mg as difference).

f) Exchangeable acidity: Extraction of Al and H with unbuffered M KCl, followed by NaOH titration. Exchangeable Al by backtitration with HCl after the addition of NaF.

g) Extractable acidity: Extraction of Al and H with $BaCl_2$- TEA buffered at pH 8.2 and followed by titration with HCl to the same end point as that of a blank.

h) Cation Exchange Capacity (CEC): is the capacity of the soil to retain cations. These exchangeable cations are the most important source of immediately available cationic plant nutrients. The method universally applied is the NH_4OAc method, whereby the soil's exchange complex is first saturated with NH_4. This NH_4 is than displaced and determined. The procedure is done at pH 7,0. For soils with a pH that differs from 7,0, this method is not realistic if the CEC is (very) dependent on the pH as is the case in allophanic Andosols.

As the pH of the volcanic ash soils (Andosols) in the project area is around 5.5 (pH KCl), the CEC-NH_4OAc values will thus be higher than the CEC in the natural soil. The difference can be considerable. A more realistic CEC value is the "effective CEC", which is the sum of the exchangeable cations and the exchangeable acidity (Al and H) determined with unbuffered M. KCl (see above, method f). However, the value of this method in Andosols high in organic matter needs further study.
A third commonly used CEC value is the "CEC sum of cations" method, i.e. the sum of the exchangeable cations and the extractable acidity (Al+H) at pH 8,2 (method g, see above). It is clear that this method grossly overestimates the natural CEC of volcanic ash soils with a low pH. On the other hand, the overestimation of the CEC is also an indication of the degree of weathering of the volcanic ash and the % variable charge (see below) is proposed as a criterion for the definition and classification of volcanic ash soils. The determinations mentioned under f,g and h were therefore not carried out on a routine basis.

i) Available Phosphorus: Kurz-Bray II: extraction with 0,1 M HCl and 0.03 M NH_4F and the colorimetric determination of the extracted P.

j) Bulk density: determined on core samples collected at 1/3 bar moisture.

k) Permeability: determined on presaturated core samples.

l) Water retention: for pF 0-2,7 determined on core samples on sand and kaolin boxes and for pF 3,7 and 4,2 with the pressure plate on membrane press extractors.

m) Consistency Values: (Atterberg liquid limit and plastic limit values) determined with the Casagrande apparatus.

n) Special analyses to characterize the character of the clay fraction of young volcanic ash soils (allophane and allophane-like amorphous materials):

- % variable charge: % of the CEC which is pH dependent
- pH NaF: pH determined in 1:50 soil: M NaF solution after 2 minutes
- P-retention: As % of P retained out of a 0,1% P solution after 24 hours shaking (soil solution = 1:5)
- total Silica and Aluminum: Al_2O_3 is dissolved by H_2SO_4, s.g.1,47, and determined titrimetrically, subsequently SiO_2 is dissolved in Na_2CO_3 and its concentration read colorimetricaly.

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2) FAO Soils Bulletin no. 10. Physical and Chemical Methods of Soil and Water Analysis. FAO Rome 1970.

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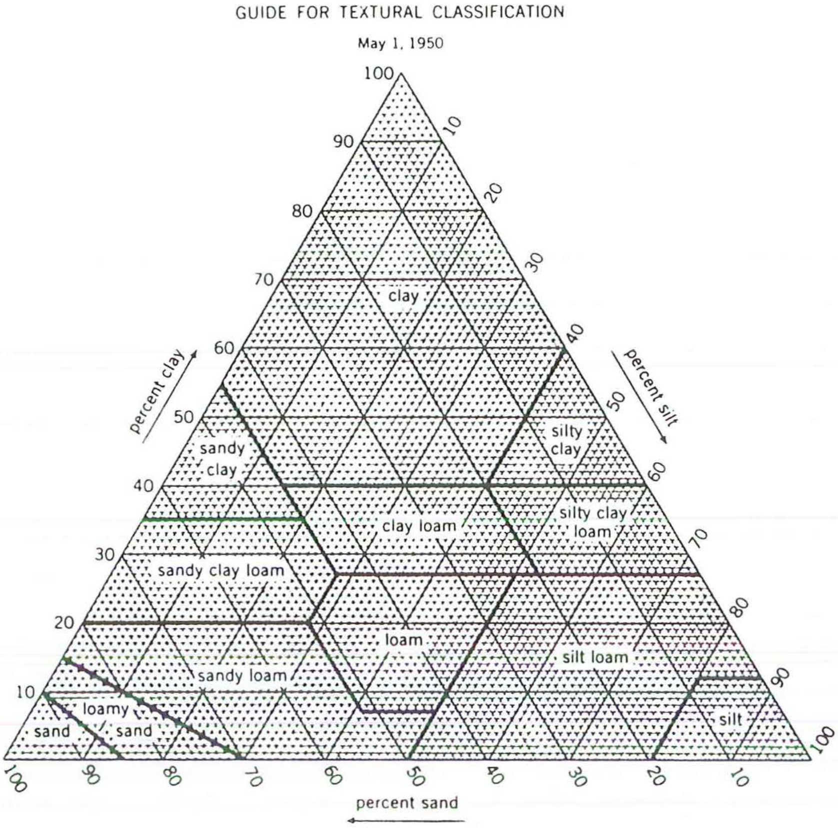
SOIL PROFILE DESCRIPTION FORM SOIL SCIENCE DEPARTMENT

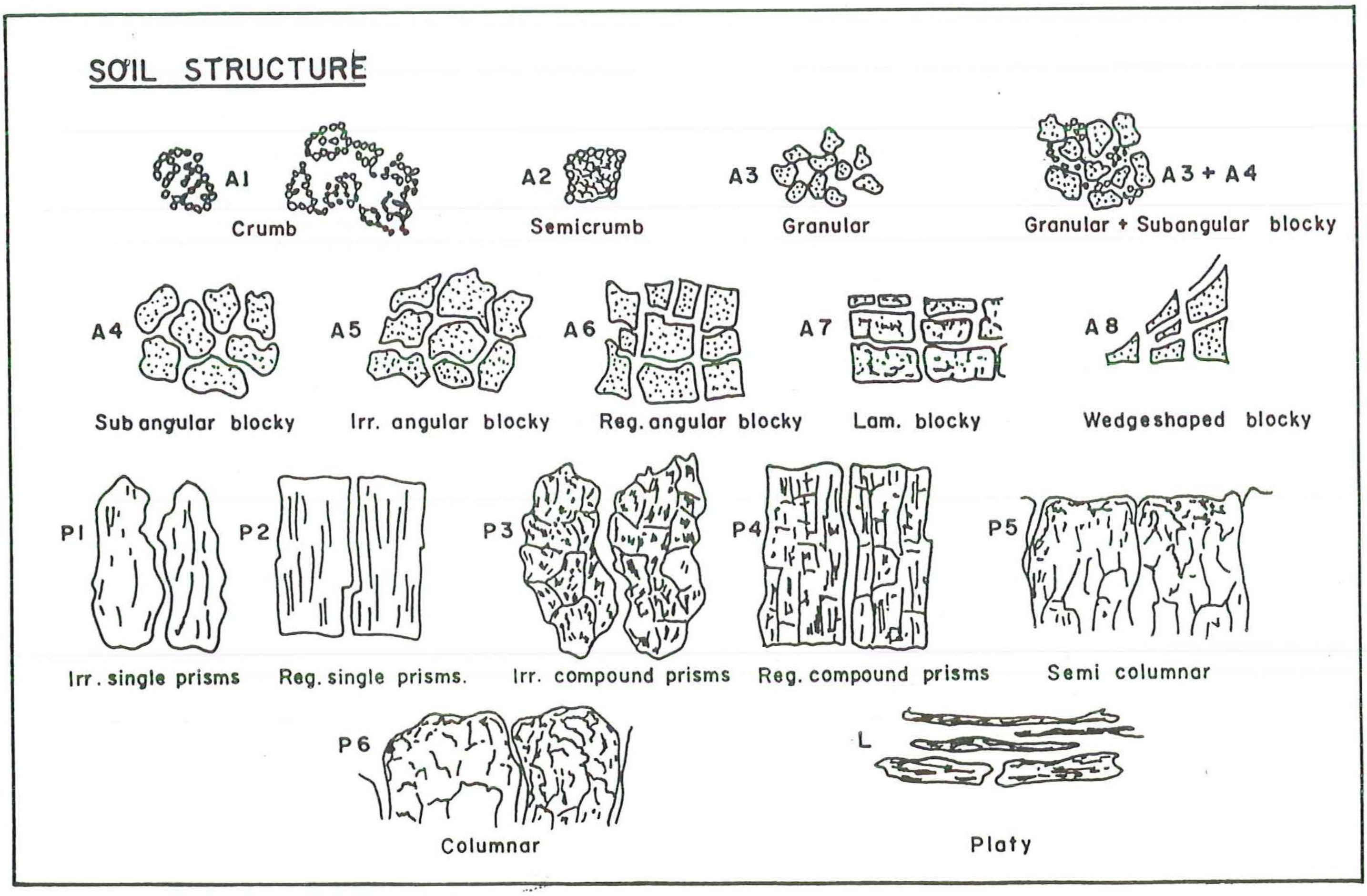
SURVEY AREA:	AERIAL PHOTO	PROFILE NO:
DATE:	DESCRIBED BY:	
SOIL SERIES:	PHASE:	
LOCATION:		
GEOMORPH. SURFACE:		ELEVATION:
PARENT MATERIAL:		
LAND USE:		
NAT. VEGETATION OR CROP:		GROUNDCOVER: %

RELIEF	Concave/flat/gently sloping/sloping/mod steep/steep/very steep
MICRORELIEF	
POSITION	top upper middle lower foothill bottom
SLOPE (%)	0-1 1-3 3-8 8-16 > 16 LENGTH (m)
EROSION	sheet rill gully CLASS: 1 2 3 4 x
ERODIBILITY	none slight moderate high very high deposition
RUNOFF	ponded very slow slow medium rapid very rapid
PERMEABILITY	none very slow slow moderate rapid very rapid
DRAINAGE	very poor poor imperfect mod.well well somewh.excess. excessive
FLOODING	none rare unusual regular frequent
ROCKS/STONES	Stoniness: non fairly stony very extremely rubble land Rockiness: non fairly stony very extremely rock land
ALKALINITY/SALIN	free slight moderate strong CODE:

REMARKS:

HORIZON	DEPTH	BOUNDARY	COLOUR	TEXTURE	STRUCTURE	CONSISTENCE D	H	W	pH	CONCRET	MOTTLES	CUTANS	ROOTS	MOISTURE	SOIL PORES
		A C G D S W I B	D H												
		A C G D S W I B	D H												
		A C G D S W I B	D H												
		A C G D S W I B	D H												
		A C G D S W I B	D H												
		A C G D S W I B	D H												
		A C G D S W I B	D H												
		A C G D S W I B	D H												
		A C G D S W I B	D H												
		A C G D S W I B	D H												
		A C G D S W I B	D H												


GUIDE FOR TEXTURAL CLASSIFICATION
May 1, 1950
percent clay
percent silt
percent sand
clay
sandy clay
silty clay
clay loam
silty clay loam
sandy clay loam
loam
silt loam
sandy loam
loamy sand
sand
silt
100
90
80
70
60
50
40
30
20
10


SOIL STRUCTURE
A1
Crumb
A2
Semicrumb
A3
Granular
A3 + A4
Granular + Subangular blocky
A4
Sub angular blocky
A5
Irr. angular blocky
A6
Reg. angular blocky
A7
Lam. blocky
A8
Wedgeshaped blocky
P1
Irr. single prisms
P2
Reg. single prisms.
P3
Irr. compound prisms
P4
Reg. compound prisms
P5
Semi columnar
P6
Columnar
L
Platy

BENDOSARI COMPLEX

Pedon No. : KK 5 (predominant soil)   SYMBOL: BC

Classification : LPT-Bogor : Eutric Cambisol
FAO : Eutric Cambisol
Soil Taxonomy : Typic Ustropept
fine loamy, isothermic family

Location : 450 m NW of entrance village Bendosari
Physiography : steep plateau side slope; position midslope
Elevation : 955 meter
Topography : steep, 20-45% (40% at pit)
Drainage : well to somewhat excessively drained; run-off rapid; permeability moderately rapid
Erosion : moderate (rill)
Landuse : wasteland; kirinyu vegetation (Eupatorium and Lantana spp with grass undergrowth)
Parent material: colluvial material derived from volcanic ash and tuff
Described by : M.Prabowo, L.Rayes and G.W.van Barneveld
25 September 1981

A1 (A1) 00-04 cm : dark brown to brown (10YR 4/3) moist; loam on handfeeling; medium weak granular and subangular blocky structure; friable, slightly sticky and slightly plastic; very slightly acid; many fine and medium roots; many fine and medium pores; clear and smooth boundary

B1 (BA) 04-16 cm : brown (10YR 5/3) moist; clay loam on handfeeling; medium weak granular and subangular blocky structure; friable, sticky and plastic; very slightly acid; common fine roots; common medium pores; clear and smooth boundary

B21 (B1w) 16-42 cm : brown (10YR 5/3) moist; clay loam on handfeeling; medium moderate angular blocky structure; friable, sticky and plastic; very slightly acid; few fine roots; common fine pores; gradual and smooth boundary

B22 (B2w) 42-90 cm : brown (10YR 5/3) moist; clay on handfeeling; medium very weak prisms breaking in medium moderate angular blocky structure; friable, sticky and plastic; few fine tuff particles; very few thin cutans on ped faces; very few fine roots; common fine pores; gradual smooth boundary

B23 (B3w) 90-120 cm : yellowish brown (10YR 5/4) moist; clay on handfeeling; medium moderate angular blocky structure; friable, sticky and plastic; very slightly acid; very few fine roots; common fine and medium pores; clear and smooth boundary

IIB (2B) 120 + : pale brown (10YR 6/3) moist; clay on handfeeling with 25% fine tuff particles; medium weak angular blocky structure; very slightly acid; friable, sticky and plastic; trace of very fine roots; common fine and medium pores

ANALYTICAL DATA   Bendosari complex

Horizon Depth (cm)		Ap 00-04	B1 04-16	B21 16-42	B22 42-90	B23 90-120
Texture		Soil does not disperse well and particle size analysis was not made; see field estimates				
organic C %		2.24	1.16	1.11	0.62	0.69
total N %		0.20	0.16	0.13	0.08	0.07
C/N		11	7	10	8	10
pH (H_2O)		6.0	5.7	6.0	6.0	6.3
pH (KCl)		5.1	5.3	5.2	4.9	5.0
exch. Ca	meq/100 grs	10.4	11.1	10.8	10.3	11.5
exch. Mg	"	5.1	4.8	5.8	5.0	5.8
exch. Na	"	0.6	0.5	0.6	0.8	1.1
exch. K	"	2.2	1.9	1.8	2.8	1.8
CEC NH_4OAc	"	25.2	23.4	20.2	21.1	21.6
Base sat.		72.6	78.2	94.0	89.6	93.5
Avail. P (Bray II) ppm		28.8	28.8	29.3	27.3	19.6
bulk density		1.09		0.95	0.98	
permeability cm/hr					8.6	
water retention						
pF 0		68.4		83.1	88.5	
pF 2		44.9		40.9	44.3	
pF 2,5		36.1		34.7	41.5	
pF 4,2		31.3		31.2	35.2	

available water 0-100 cm : 52.7 mm

COBAN RONDO SERIES

Pedon No. : KK 11 SYMBOL: C

Classification : LPT-Bogor : Humic Andosol
FAO : Humic Andosol
Soil Taxonomy : Typic Dystrandept, medial isothermic family

Location : footpath Bendosari - top G.Kawi at 1600 meter
Physiography : steeply dissected upperslopes (position : Crest)
Elevation : 1600 meter
Topography : crestslope 35%; valley side slopes 55-60%
Drainage : well drained; rapid run-off; very rapid permeability
Erosion : moderately eroded (sheet and rill)
Vegetation : Casuarina forest with undergrowth of Eupatorium
Parent material: volcanic ash over tuff
Described by : M. Prabowo, L. Rayes and G.W.van Barneveld
12 October 1981

A1 (A1) 00-20 cm : black (10YR 2/0) moist; loam to sandy loam on handfeeling with some fine ash and tuff gravels and nodules; medium moderate subangular blocky structure; friable, slightly plastic and slightly sticky; slightly acid; many roots; many fine and medium pores; clear, smooth boundary

A3 (AB) 20-37 cm : very dark brown (10YR 2/2) moist; loam on handfeeling with few fine semi-cemented ash nodules; medium, moderate to weak subangular blocky structure; very friable, slightly sticky, slightly plastic; slightly acid; many roots; many fine and medium pores; clear, wavy boundary

B21 (B1w) 37-75 cm : dark yellowish brown (10YR 4/6) moist; clay loam on handfeeling with 5-10% fine ash nodules; medium, weak angular blocky structure; very friable, slightly sticky, slightly plastic; slightly acid; many roots; many fine, few medium pores; clear, smooth boundary

B22 (B2w) 75-119 cm : dark yellowish brown (10YR 4/4) moist; clay loam on handfeeling; medium, weak angular blocky structure; very friable, sticky and plastic; slightly acid; common fine roots; many fine and few medium pores;clear smooth boundary

IIB (2Bw) 119-132 cm : dark brown to dark yellowish brown (10YR 4/3,5) moist; clayey on handfeeling with 10% tuff gravels up to 2 cm Ø; medium, moderate to weak angular blocky structure; friable, sticky and plastic; acid; very few fine roots; many fine and common medium pores; abrupt, smooth boundary

IIC (2C) 132-155+cm : yellowish brown to brownish yellow (10YR 5/6 to 6/8) moist; semi-weathered tuff with sandy clay loam texture on handfeeling; medium weak angular blocky structure; friable, sticky and plastic; acid; common fine pores

ANALYTICAL DATA — Coban Rondo Series

Horizon	A1	A3	B21	B22	IIB
Depth (cm)	00-20	20-37	37-75	75-119	119-132
Texture	Soil does not disperse well and particle size analysis was not made; see field estimates				
organic C%	8.48	6.17	2.66	2.70	1.07
total N %	0.60	0.47	0.21	0.19	0.05
C/N	14	13	13	14	21
pH (H_2O)	5.8	6.2	5.9	5.8	5.4
pH (KCl)	4.3	4.9	5.0	5.1	4.1
exch. Ca meq/100 grs	8.8	4.1	3.8	5.4	4.6
exch. Mg "	1.9	0.9	1.0	2.0	1.4
exch. Na "	0.2	0.1	0.4	0.4	0.6
exch. K "	0.3	0.2	0.2	0.4	0.3
exch. acidity (pH 7)	0.2	0.2	0.2	0.2	0.35
extr. acidity (pH 8.2)	39.0	39.9	39.0	30.2	18.6
CEC (NH_4OAc) "	38.2	36.2	34.3	36.4	28.4
CEC effective"	11.4	5.5	5.6	8.4	7.2
CEC sum cations "	50.2	45.2	44.4	38.4	25.5
Base sat. (NH_4OAc)	29.3	14.6	15.7	22.5	24.3
Base sat. (effective)	98	96	96	98	96
Base sat. (sum cations)	22.3	11.7	12.1	21.3	27.0
Avail. P (Bray II)	49.4	40.9	20.6	20.6	17.4
P-retention %	84	97	98	99	96
pH (NaF)	10.9	10.9	11.0	10.1	10.0
Variable charge %	77.3	87.8	87.4	78.1	71.8
bulk density	0.83		0.47		
permeability cm/hr	43,5		27,5		
water retention %					
pF 0	108.6		195.1		
pF 2	69.4		142.1		
pF 2.5	59.7		94.2		
pF 4.2	39.5		63.5		

GOMBONG ASSOCIATION

Pedon No. : KK 25 SYMBOL : GA

Classification : LPT-Bogor : Melanic-Vitric* Andosol
FAO : Humic-Vitric* Andosol
Soil Taxonomy : Umbric Vitrandept, medial over cindery, isohyperhtermic family

Location : 2 km SW, Desa Ngantru
Physiography : colluvial foothills, Gunung Kelud
Elevation : 800 meter
Topography : hilly 15-30%
Drainage : somewhat excessively drained
Erosion : slight (rill)
Vegetation : Mahoni plantation with grass undergrowth
Parent material: volcanic ash and pumice
Described by : L. Rayes, Sudarto , G.W.van Barneveld and G. Cosijn
5 March 1983

A11 (A1) 00-17 cm : very dark brown (10YR 2/2) moist; sandy loam on handfeeling with 5% pumice gravels (1-2 cm Ø); medium to fine moderate granular structure; friable, slightly sticky and slightly plastic; very slightly acid; many fine and medium roots; many fine, medium and coarse pores; clear smooth boundary

A12 (A2) 17-26 cm : dark brown (7,5 YR 3/2) moist; sandy loam on handfeeling with 3% pumice gravels up to 1 cm Ø ; medium, moderate granular and subangular blocky structure; friable, slightly sticky and slightly plastic; very slightly acid; many fine and medium roots; many fine, medium and coarse pores; abrupt wavy boundary

C (C) 26-49 cm : yellowish brown (10YR 5/8) moist; coarse pumice layer (5-6 cm Ø); loose; friable, non sticky non plastic; very slightly acid; common fine and medium roots; abrupt wavy boundary

IIA (2A) 49-68 cm : black (10YR 2/1) moist; loam on handfeeling with 1% pumice gravels 1,5 cm; medium moderate subangular and angular blocky structure; friable, non sticky, slightly plastic; very slightly acid; common fine roots; many fine, medium and coarse pores; gradual wavy boundary

IIB21 (2Bw): 68-109 cm dark yellowish brown (10YR 3/4) moist; sandy loam on handfeeling with very few pumice gravels up to 1 cm Ø; medium moderate angular blocky structure; friable, non sticky, slightly plastic; very slightly acid; few fine roots; common fine, medium and coarse pores; clear smooth boundary

IIB22 (2Bw): 109-127 cm dark yellowish brown (10YR 3/4) moist; coarse sandy loam with 30-40% pumice gravels up to 3 cm Ø; medium moderate angular blocky structure; friable, non sticky, non plastic; very slightly acid; few fine roots; few fine, medium and coarse pores; abrupt smooth boundary

ANALYTICAL DATA

Gombong Association

Horizon Depth (cm)	A11 00-17	A12 17-26	IIA 49-68	IIB21 68-109	IIB22 109-127
Texture	Soil does not disperse well and particle size analysis was not made; see field estimates				
Organic C %	2.3	2.0	2.6	1.3	0.7
Total N %	0.19	0.19	0.18	0.13	0.07
C/N	12	11	14	10	10
pH (H_2O)	6.3	6.2	6.2	6.3	6.4
pH (KCl)	4.9	5.0	4.8	4.9	4.9
exch. Ca meq/100 grs	4.2	3.9	6.4	6.5	7.4
exch. Mg "	1.8	1.3	1.7	1.7	1.3
exch. Na "	0.3	0.3	0.5	0.3	0.4
exch. K "	0.4	0.3	1.0	0.8	0.7
CEC NH_4 OAc "	13.7	16.0	17.7	17.6	16.0
Base sat. NH_4OAc %	49	36	54	53	61
Avail. P ppm (Bray II)	54	36	9	9	19
Variable charge %	10.7	11.0	11.0	11.1	11.0
bulk density	0,85		0,85	0,70	

GUNUNG BUTAK SERIES

Pedon No. : KK 14 SYMBOL : GB

Classification : LPT-Bogor : Humic Andosol
FAO : Humic Andosol
Soil Taxonomy : Hydric Dystrandept, medial over thixotropic, isomesic family

Location : footpath Bendosari - top G.Kawi at 2450 meter
Physiography : steeply dissected upper slopes (position: crest)
Elevation : 2450 meter
Topography : crestslope 30%; valley side slopes 85-90%
Drainage : well drained; rapid run-off; rapid permeability
Erosion : slight
Vegetation : Casuarina forest with grass undergrowth
Parent material: volcanic ash
Described by : M.Prabowo, L.Rayes and G.W.van Barneveld
11 October 1981

01 (Oi) -6-00 cm : organic litter layer

A11 (A1) 00-12 cm : black (10YR 2/1) moist; sandy loam on handfeeling with few weathered ash nodules 1-1,5 cm Ø ; medium moderate granular and subangular blocky structure; friable, non sticky and slightly plastic, slightly thixotropic; very slightly acid; many roots; many fine and medium pores; clear, smooth boundary

A12 (A2) 12-34 cm : black (10YR 2/1) moist; loam on handfeeling with 5% weathered ash noules 1-1,5 cmØ ; medium, moderate granular and subangular blocky structure; friable, non sticky and slightly plastic, slightly thixotropic; acid; many roots; many fine and medium pores; clear, smooth boundary

A13 (A3) 34-46 cm : black (10YR 2/1) moist; loam on handfeeling with few fine tuff particles; medium, moderate granular and sub-angular blocky structure; friable, slightly sticky,slightly plastic, slightly thixotropic; acid; many fine roots; many fine and medium pores; clear and smooth boundary

A3 (AB) 46-64 cm : black to very dark brown (10YR 2/1,5) moist; loam to clay-loam on handfeeling with few weathered ash nodules; medium moderate angular blocky structure; friable, sticky and plastic, slightly thixotropic; acid; common fine roots; many fine and medium pores; clear and irregular boundary

B2 (Bw) 64-105 cm : strong brown (7,5YR 4/6) moist; clay loam on handfeeling with few weathered ash nodules; medium weak angular blocky structure; friable, sticky and plastic, slightly thixo-tropic; very slightly acid; few fine roots; many fine and medium pores; clear and smooth boundary

IIB (2 Bw) 105-108+ : dark yellowish brown (10YR 3/6) moist; clay on handfeeling developed from weathered andesite; friable, sticky and plastic, slightly thixotropic; acid; common fine pores

ANALYTICAL DATA

Gunung Butak series

Horizon	A11	A123	A3	B2	IIB
Depth (cm)	00-12	12-46	46-64	64-105	105+
Texture	Soil does not disperse well and particle size analysis was not made; see field estimates				
organic C %	6.71	8.48	7.02	2.35	1.74
total N %	0.58	0.68	0.59	0.18	0.14
C/N	12	12	12	13	12
pH (H_2O)	6.5	5.4	5.8	6.2	5.5
pH (KCl)	4.6	4.6	4.9	5.5	4.5
exch. Ca meq/100 grs	0.2	0.6	0.4	0.4	0.5
exch. Mg "	0.2	0.3	0.3	0.4	0.4
exch. Na "	0.4	0.5	0.4	0.2	0.4
exch. K "	0.3	0.3	0.2	0.2	0.2
exch. acidity (pH 7)	0.5	0.7	0.3	0.25	0.3
extr. acidity (pH 8.2)	29.6	39.6	35.6	32.0	29.6
CEC NH_4OAc " pH 7	17.9	27.2	28.0	23.2	28.0
CEC effective "	1.6	2.4	1.6	1.4	1.8
CEC sum of cations	30.7	41.3	36.9	33.2	31.1
Base sat. NH_4OAc % pH 7	6.1	6.2	4.6	5.2	5.3
Base sat. effective %	68.7	70.8	81.2	85.7	83.3
Base sat. sum cations %	3.6	4.1	3.5	3.6	4.8
Avail. P ppm (Bray II)	33.5	28.8	24.2	24.2	21.1
P-retention %	52	82	86	92	99
pH (NaF)	10.8	10.6	10.8	10.4	9.9
Variable charge %	94.8	94.2	95.7	95.8	94.2
bulk density	0.78			0.51	
liquid limit	66.3			162.4	
plastic limit	-			135.2	
plasticity index	-			27.2	
permeability cm/hr	36			12,5	
water retention %					
pF 0	91.2			226.5	
pF 2	53.1			148.1	
pF 2,5	40.3			115.1	
pF 4,2	19.5			67.7	

GUNUNG KELUD COMPLEX

Pedon No. : KK 33 SYMBOL : GK

Classification : LPT-Bogor : Mollic-Vitric* Andosol
FAO : Mollic-Vitric* Andosol
Soil Taxonomy : Mollic Vitrandept, ashy over cindery, isothermic

Location : 5,1 km SW of Desa Ngantru
Physiography : steep mountain slopes of Gunung Kelud
Elevation : 1090 meter
Topography : position crest; 40-45 % slopes
Drainage : excessively drained, moderate run-off; rapid permeability
Erosion : moderate rill erosion
Vegetation : scrub vegetation (Eupatorium and Lantana spp)
Parent material: volcanic ash and pumice
Described by : L. Rayes and G.W.van Barneveld 21 May 1983

A1 (A1) 00-12 cm : black (10YR 2/0) moist; loam on handfeeling with very few pumice gravels; medium, moderate granular and subangular blocky structure; friable, non sticky, non plastic; very slightly acid; many fine and medium roots; many fine, medium and coarse pores; clear wavy boundary

AC (AC) 12-19 cm : brown (10YR 5/3) moist; sandy loam on handfeeling with 10% pumice and andesitic gravels up to 2 cm Ø; medium, very weak angular blocky structure; friable, non sticky, non plastic; neutral; many fine and medium roots; many, fine, medium and coarse pores; clear, smooth boundary

IIA1 (2A1) 19-38 cm : very dark brown (10YR 2/2) moist; sandy loam on handfeeling with 20% pumice and andesitic gravels up to 5 cm Ø; medium, moderate subangular blocky structure;friable, non plastic, non sticky; neutral; many fine roots; many fine, medium and coarse pores; clear, smooth boundary

IIAC (2AC) 38-48 cm : brown (10YR 5/3) moist; sand with 70-80% pumice gravel up to 5 cmØ ; medium, very weak angular blocky structure; friable, non sticky, non plastic; neutral; few, fine roots; many fine, medium and coarse pores; clear, smooth boundary

IIIA1(3A1) 48-59 cm : very dark brown (10YR 2/2) moist; loamy sand on handfeeling with 50% pumice gravels up to 5 cm Ø; medium, very weak subangular blocky structure; friable, non plastic, non sticky; neutral; few, fine roots; many fine, medium and coarse pores; clear, smooth boundary

IIIC (3C) 59-145 cm + : pumice gravel layer, loose with individual pumice gravels up to 5 cm Ø.

ANALYTICAL DATA

Gunung Kelud complex

Horizon	A1	IIA1	IIAC	IIIA1
Depth (cm)	00-12	19-38	38-48	48-59
Texture	the soil does not disperse well and particle size analysis was not made; see the field estimates			
organic C %%	7.1	2.5	1.6	2.4
total N %	1.08	0.28	0.30	0.24
C/N	7	9	5	10
pH (H_2O)	6.3	6.5	6.5	6.6
pH (KCl)	5.8	5.9	5.9	5.8
exch. Ca meq/100 grs	32.1	15.9	10.2	12.8
exch. Mg "	2.8	3.6	6.9	7.0
exch. Na "	0.4	0.3	0.2	0.2
exch. K "	0.6	1.0	tr	tr
extr. acidity (pH 8.2)	17.3	12.0	8.6	13.2
CEC NH_4OAc "	64.7	24.5	26.8	25.0
CEC effective	73.2	32.8	25.9	33.2
Base sat. NH_4OAc %	56	85	65	80
Avail. P ppm (Bray II)	74	63	54	28
P - retention %	12	23	21	73
pH (NaF)	9.0	10.5	10.4	10.7
bulk density	0.76	0.73	0.77	0.79

GUNUNG KELUD COMPLEX

Pedon No. : KK 35 SYMBOL : GK

Classification : LPT-Bogor : Melanic-Vitric* Andosol
FAO : Vitric-Melanic* Andosol
Soil Taxonomy : Typic Vitrandept, ashy over cindery, isothermic family

Location : 3,2 km SW of Desa Ngantru
Physiography : steep mountain slopes of Gunung Kelud
Elevation : 950 meter
Topography : position crest, 40-55% slopes
Drainage : excessively drained, moderate run-off; rapid permeability
Erosion : moderate rill erosion
Vegetation : Pinus plantation, Kirinyu
Parent material: volcanic ash and pumice
Described by : M.L.Rayes and G.W.van Barneveld 24 May 1983

A11 (A1) 00-10 cm : black (10YR 2/1) moist; sandy loam on handfeeling with 2% pumice gravels<3 cm Ø; medium moderate granular and subangular blocky structure; friable, non sticky, non plastic; very slightly acid; many fine and medium roots; many fine, medium and coarse pores; clear wavy boundary

A3 (AB) 10-24 cm : dark brown (10YR 3/3)moist; sandy loam on handfeeling with 3% pumice gravels <3 cm Ø; medium weak subangular and angular blocky structure; friable, non sticky, non plastic; very slightly acid; many fine and medium roots; many fine, medium and coarse pores; clear wavy boundary

AC (AC) 24-46 cm : brown (10YR 4/3)moist; sandy to sandy loam on handfeeling with 60-70% pumice gravels up to 5 cm Ø; medium, very weak subangular and angular blocky structure; friable, non sticky, non plastic; very slightly acid; many medium roots; many fine, medium and coarse pores; clear wavy boundary

IIC (2C) 46-82 cm : yellowish brown (10 YR 5/6)moist; pumice layer; loose; friable, non sticky, non plastic; many fine roots; clear wavy boundary

IIIA1(3A1) 82-95 cm : black (10YR 2/1) moist; sandy loam to loam on handfeeling with 5% pumice gravels up to 2 cm Ø; medium weak granular and subangular blocky structure; friable, non sticky, non plastic; neutral; few fine and medium roots; many fine, medium and coarse pores; clear wavy boundary

IIIB1 (3BA) 95-113 cm : dark brown (10YR 3/3)moist; loam on handfeeling with 3% pumice gravels up to 1 cm Ø; medium weak subangular and anular blocky structure; friable, slightly sticky non plastic; neutral; few fine roots; many fine, medium and coarse pores; clear wavy boundary

IIIB21 (3Bw) 113-135 cm : dark yellowish brown (10YR 4/6) moist; loam on handfeeling with 5% pumice gravels up to 2 cm Ø; medium moderate angular blocky structure; friable,slightly sticky non plastic; neutral; few fine roots; few fine and common medium and coarse pores; clear wavy boundary

ANALYTICAL DATA

Gunung Kelud complex

Horizon	A11	A3	AC	IIIA1	IIIB1	IIIB21
Depth (cm)	00-10	10-24	24-46	82-95	95-113	113-135
Texture	Soil does not disperse well and particle size analysis was not made; see field estimates					
Organic C %	3.4	3.0	2.4	2.6	2.1	1.0
Total N %	0.44	0.40	0.36	0.25	0.28	0.17
C/N	8	8	7	10	8	6
pH (H_2O)	6.3	6.3	6.5	6.6	6.6	6.7
pH (KCl)	5.9	5.9	6.0	5.9	5.9	5.8
exch. Ca meq/100 grs	5.3	19.0	13.6	21.1	14.1	8.4
exch. Mg "	10.0	8.5	9.0	7.0	10.7	5.9
exch. Na "	0.4	0.5	0.3	0.4	0.4	0.3
exch. K "	-	0.6	0.1	0.3	0.3	-
CEC NH_4OAc "	17.4	29.8	23.3	30.1	27.2	19.8
CEC effective"	30.1	42.1	34.7	49.6	43.1	30.0
Base sat. NH_4OAc %	90	96	99	96	94	74
Base sat. effective %	52	68	66	58	59	49
Avail. P ppm (Bray II)	81	79	57	25	59	24
P-retention %	24	26	30	67	68	61
pH (NaF)	10.0	10.6	10.6	10.9	11.0	11.0

JABON SERIES

Pedon No. : KK 39 SYMBOL : NA

Classification : LPT-Bogor : Mollic Cambisol
FAO : Haplic Phaeozem
Soil Taxonomy : Fluventic Hapludoll, fine loamy, isohyperthermic

Location : 750 meter SE from Desa Jabon
Physiography : lower intervolcanic plain
Elevation : 660 meter
Topography : very gently sloping 3-5%
Drainage : well drained
Erosion : none
Vegetation : kebun: coffee, banana, coconut, cassava, cocoyam
Parent material: fine textured lahar and volcanic ash material
Described by : M.Prabowo, L. Rayes and G.W.van Barneveld 10 June 1983

A1 (A1) 00-20 cm : very dark grayish brown to very dark brown (10YR 2,5/2) moist; sandy clay loam with 2% andesitic gravel < 1 cm Ø; medium, moderate granular and subangular blocky structure; slightly sticky, non plastic; very slightly acid; common fine roots; many fine, medium and coarse pores; clear, wavy boundary

A3 (AB) 20-40 cm : very dark grayish brown to very dark brown (10YR 2,5/3) moist; sandy clay loam with 5% andesitic gravels < 2 cm Ø; medium, moderate angular blocky structure; slightly sticky, slightly plastic; slightly acid; few fine roots; common fine and medium and few coarse pores; abrupt, smooth boundary

II (2B) 40-55 cm : brown to dark brown (10YR 4/3) moist; sandy clay loam to sandy loam with 10% andesitic gravel < 0,5 cm Ø; stratified and loose; slightly sticky, non plastic; very slightly acid; few fine roots; many fine, medium and coarse pores; abrupt, smooth boundary

IIIB2 (3B) 55-71 cm : dark brown (10YR 3,5/3) moist; clay loam with few andesitic gravel < 0,5 cm Ø ; medium, moderate angular blocky structure; sticky and plastic; neutral; very few patchy cutans on ped faces; few fine roots; common fine, medium and many coarse pores; clear, smooth boundary

IIIB3(3BC) 71-88 cm : yellowish brown (10YR 5/8) moist; loam; medium, weak angular blocky structure; slightly sticky, non plastic; neutral, common fine distinct FeMn mottles; very few fine roots; common fine and medium and many coarse pores; clear smooth boundary

IVA (4A) 88-114 cm : brown to dark brown (10YR 4/3) moist; clay loam; medium, moderate angular blocky structure; slightly sticky, slightly plastic; slightly acid; trace roots; many fine, medium and common coarse pores

IVB1 (4BA) 114-123 cm : light yellowish brown to a yellowish brown (10YR 5,5/4) moist; clay loam on handfeeling; medium, moderate angular blocky structure; slightly sticky and slightly plastic; very slightly acid; common, medium, distinct FeMn mottles; very few fine roots; few fine, medium and coarse pores

ANALYTICAL DATA Jabon series

Horizon Depth (cm)	A1 00-20	B 20-40	II 40-55	IIIB2 55-71	IIIB3 71-88	IVA 88-114
total clay %	21	25	22	29	24	34
total silt %	23	21	6	28	38	46
total sand %	56	54	72	43	38	20
very fine sand %	7	5	2	7	14	5
fine sand %	19	18	10	15	10	6
medium sand %	20	20	26	13	8	5
coarse sand %	8	9	24	6	5	3
very coarse sand %	2	2	10	2	1	1
organic C %	0.7	0.6	0.4	0.5	0.5	0.3
total N %	0.08	0.07	0.05	0.09	0.07	0.06
C/N	9	9	8	6	7	5
pH (H_2O)	6.1	6.0	6.1	6.6	6.6	6.5
pH (KCl)	4.7	4.9	4.9	5.0	4.8	4.9
pH (NaF)	9.8	9.7	9.3	9.6	9.7	9.8
exch. Ca meq/100 grs	7.9	14.5	12.3	10.3	13.5	29.3
exch. Mg "	0.6	3.2	5.8	4.9	4.6	4.4
exch. Na "	0.3	0.4	0.6	0.6	0.8	0.7
exch. K "	tr	0.4	0.7	1.2	1.7	1.8
CEC NH_4OAc "	11.1	19.7	20.3	17.1	26.7	37.5
Base sat. NH_4OAc	79	94	96	99	77	97
Avail. P ppm (Bray II)	8.0	6.0	12.0	9.0	7.0	8.0

JOMBOK SERIES

Pedon No. : KK 27 . SYMBOL : J

Classification : LPT-Bogor : Anthropic* Mollic Cambisol
FAO : Anthropic* Haplic Phaeozem
Soil Taxonomy : Anthropic* Andic* Hapludoll
fine clayey, isohyperthermic family

Location : 2,4 km NE of Desa Jombok
Physiography : hillslopes, terraced
Elevation : 790 meter
Topography : 35-50% slopes
Drainage : moderately well drained; rapid run-off; moderate permeability
Erosion : moderate rill and small gully erosion
Vegetation : Pennisetum purpureum on agro forestry land
Parent material: colluvial materials derived from volcanic ash
Described by : Sudarto, L. Rayes and G.W.van Barneveld
19 May 1983

Ap (Ap) 00-11 cm : dark brown (10YR 3/3) moist; loam to clay loam on handfeeling; medium moderate granular and subangular blocky structure; friable, slightly sticky, slightly plastic; very slightly acid; many fine roots; many fine, medium and coarse pores; clear smooth boundary

A1 (A1) 11-22 cm : dark brown (10YR 3/3) moist; clay loam on handfeeling; medium moderate subangular blocky structure; friable, slightly sticky, slightly plastic; very slightly acid; common fine roots; many fine, medium and coarse pores; clear smooth boundary

B1 (BA) 22-35 cm : brown (10YR 4/3) moist; clay loam to clay on handfeeling with 5% tuff particles; medium moderate subangular and angular blocky structure; friable,slightly sticky, slightly plastic; very slightly acid; common fine roots; many fine, medium and coarse pores; few fine FeMn concretion; common fine FeMn mottles; patchy thin clay cutans; clear smooth boundary

B21 (B1w) 35-77 cm : dark yellowish brown (10YR 4/4) moist; clay on handfeeling with 5% tuff particles; medium moderate angular blocky structure; friable; slightly sticky and plastic; very slightly acid; few fine FeMn concretions; common fine distinct FeMn mottles; patchy thin clay cutans; common fine, medium and coarse pores; gradual smooth boundary

B22 (B2w) 77+ cm : dark yellowish brown (10YR 4/4) moist; clay on handfeeling with 20% weathered andesit tuff and 5% fine andesitic gravel; medium moderate angular blocky structure; firm, sticky and plastic; very slightly acid; patchy thin clay cutans; common fine, medium and coarse pores

ANALYTICAL DATA

Jombok series

Horizon	Ap	A1	B1	B21	B22
Depth	00-11	11-22	22-35	35-77	77 +
Texture	Soil does not disperse well and particle size analysis was not made; see field estimates				
Organic C %	2.1	3.3	0.5	0.3	0.3
Total N %	0.28	0.43	0.09	0.04	0.04
C/N	8	8	6	8	8
pH (H_2O)	6.3	6.1	6.5	6.4	6.2
pH (KCl)	4.6	4.1	4.2	4.2	4.8
exch. Ca meq/100 grs	12.5	10.0	11.7	12.2	14.6
exch. Mg "	8.2	11.2	5.5	12.9	12.6
exch. Na "	1.1	0.4	0.4	0.4	0.4
exch. K "	1.5	0.5	0.1	0.1	tr
CEC NH_4OAc "	32.1	35.3	28.1	31.9	30.5
Base sat. NH_4OAc %	73	63	63	80	91
Avail. P ppm (Bray II)	2	2	4	3	6
pH (NaF)	9.7	9.9	10.0	9.9	10.4

KALI KONTO COMPLEX

Pedon No. : KK 3 (predominant soil) SYMBOL : KC

Classification : LPT-Bogor : Anthraquic* Eutric Cambisol
FAO : Anthraquic* Eutric Cambisol
Soil Taxonomy : Anthraquic* Eutropept, loamy skeletal, isohyperthermic family

Location : Kedungrejo; 200 m W of bridge over Kali Konto
Physiography : U-shaped alluvial valley
Elevation : 885 meter
Topography : sloping, 12% slope; terraced land
Drainage : imperfectly drained (altered drainage); medium run-off; slow permeability (estimate)
Erosion : none
Landuse : irrigated agriculture; rice, maize and vegetables
Parent material: alluvial deposits, clayey and stony of volcanic origin
Described by : M. Prabowo and G.W.van Barneveld
25 September 1982

Ap (Ap) 00-17 cm : black (10YR 2/1) moist; loam with few fine andesitic gravels up to 1 cm Ø; medium, moderate granular and subangular blocky structure; friable, slightly sticky, plastic; acid; common fine roots; many fine and medium pores; clear, smooth boundary

A1 (A1) 17-30 cm : very dark gray (10YR 3/1) moist; loam with few fine andesitic gravels up to 1 cm Ø; medium moderate angular blocky structure; friable, sticky and plastic; slightly acid; common, medium distinct Fe mottles; few fine roots; common fine pores; clear smooth boundary

B (B) 30-49 cm : black (10YR 2/1) moist; loam with 5% gravels up to 3 cm Ø; medium, moderate to weak prisms breaking into medium moderate angular blocky structure; friable, sticky and plastic; very slightly acid;many medium distinct Fe mottles; few fine cutans on ped faces; common fine pores; abrupt smooth boundary

IIA (2A) 49-64 cm : very dark gray (10YR 3/1) moist; loam with 75% rounded stones up to 20 cm Ø; medium weak angular blocky structure; friable, non sticky, non plastic; almost neutral; few fine FeMn mottles; common fine pores; clear and smooth boundary

IIB2(2 Bw) 64-89 cm : very dark grayish brown (10YR 3/2) moist; clay loam on handfeeling with 10% rounded gravel up to 10 cm Ø; medium weak prisms breaking into medium moderate angular blocky structure; friable, sticky and plastic; neutral; few, fine FeMn mottles; few fine cutans on ped faces; common fine pores; abrupt to clear, smooth boundary

IIB3(2 BC) 89- + cm : dark brown (10YR 3/3) moist; clay on handfeeling with 45% rounded andesitic gravel and stones up to 10 cm Ø; medium moderate angular blocky structure; friable, sticky and plastic; slightly acid; common fine Fe mottles; common fine pores and few fine cutans on ped faces

ANALYTICAL DATA

Kali Konto complex

Horizon Depth (cm)	Ap 00-17	A1 17-30	B 30-49	IIA 49-64	IIB2 64-89	IIB3 89-117
total clay %	24.6	18.6	20.9	16.7		
total silt %	42.0	42.9	41.9	39.4		
very fine sand %	4.3	4.6	4.8	4.4		
fine sand %	13.3	16.3	14.9	18.9		
medium sand %	9.4	10.7	12.3	13.0		
coarse sand %	4.0	5.1	3.8	5.1		
very coarse sand %	2.3	1.9	1.5	2.5		
organic C %	1.31	1.16	0.85	0.77	0.42	0.23
total N %	0.14	0.11	0.10	0.08	0.06	0.05
C/N	9	11	9	10	7	5
pH (H_2O)	5.5	6.0	6.4	6.6	6.9	5.9
pH (KCl)	4.8	5.3	5.6	5.6	5.4	5.4
exch. Ca meq/100 grs	12.3	14.0	14.3	13.9	16.4	
exch. Mg "	7.1	7.2	7.3	7.3	7.4	
exch. Na "	0.9	0.9	0.8	1.1	1.0	
exch. K "	0.5	0.6	2.0	1.5	1.6	
CEC (NH_4OAc) "	38.2	35.4	30.8	29.4	29.5	
Base sat %	55.7	64.1	79.2	80.9	89.5	
available P (Bray II)	33.5	31.8	18.8	18.5	19.3	

KALI SERENG ASSOCIATION

Pedon No. : KK 8 SYMBOL : SA

Classification :	LPT-Bogor	: Mollic Andosol
	FAO	: Mollic Andosol
	Soil Taxonomy	: Cumulic Mollic Eutrandept medial isohyperthermic family

Location : 1250 m SSE of Bakir village
Physiography : U-shaped valley floor; tributary Kali Sereng
Elevation : 1125 meter
Topography : nearly flat valley floor (1-2%)
Drainage : moderately well drained; run-off medium to slow; permeability moderate; flooding rare; groundwater table at 140 cm
Erosion : deposition
Landuse : farmland: coffee, banana, avocado and undergrowth of grass
Parent material: alluvial and colluvial materials derived from volcanic ash and tuff
Described by : M.Prabowo, L. Rayes and G.W.van Barneveld
5 October 1981

A11 (A1) 00-10 cm : black (10YR 2/1) moist; loam on handfeeling; medium moderate to weak granular and subangular blocky structure; friable, non sticky and non plastic; slightly acid; many fine roots; very porous; clear and wavy boundary

A12 (A2) 10-36 cm : black to very dark gray (10YR 2,5/1) moist; loam to sandy loam on handfeeling; medium moderate granular and subangular blocky structure; friable, non sticky and non plastic; slightly acid; common fine roots; very porous; clear and wavy boundary with a few lenses of coarse ash material

B (Bw) 36-61 cm : black to very dark gray (10YR 2,5/1) moist; clay loam on handfeeling; very weak medium prisms breaking into medium weak angular blocky structure; friable, sticky and plastic; slightly acid; few fine distinct Fe mottles; few fine cutans on ped faces; few fine roots; common fine and medium pores; clear and wavy boundary

II (2 Bw) 61-73 cm : very dark grayish brown (10YR 3/2) moist; sandy clay loam on handfeeling; medium weak angular blocky structure; friable, sticky and plastic; very slightly acid; few fine distinct Fe mottles; very few fine roots; common fine and medium pores; abrupt and wavy boundary

IIIA(3A) 73-90 cm : black (10YR 2/1) moist; loam to sandy clay loam on handfeeling; medium weak angular to subangular blocky structure; friable, sticky and plastic; very slightly acid; very few fine roots; abrupt and smooth boundary

III (3B) 90-100 cm : very dark brown (10YR 2/2); layers and bands of clay, loam, sandy loam and sandy clay loam materials; weak platy and angular blocky structure; friable; very slightly acid; few fine and distinct Fe mottles; very few fine roots; common fine pores; abrupt and smooth boundary

IVB1 (4BA) 100-120 cm : black to very dark gray (10YR 2,5/1) moist; clayey with 10% sandsize tuff particles; medium weak prisms breaking in medium moderate angular blocky structure; friable, sticky and plastic; many medium distinct Fe mottles; very few fine roots; few fine pores; gradual and smooth boundary

ANALYTICAL DATA Kali Sereng association

Horizon	A11	A12	B	II	IIIA	IVB
Depth (cm)	00-10	10-36	36-61	61-73	73-90	100-120
Texture	Soil does not disperse well and particle size analysis was not made; see field estimates					
organic C %	6.28	5.40	4.44	3.24	4.21	2.77
total N %	0.43	0.38	0.33	0.23	0.29	0.24
C/N	15	14	13	14	14	12
pH (H_2O)	5.6	5.9	5.7	6.1	6.1	6.0
pH (KCl)	4.8	4.9	5.3	5.3	4.7	4.6
exch. Ca meq/100 grs	9.3	9.4	10.2	9.6	9.8	9.7
exch. Mg "	3.1	3.1	4.2	3.7	3.8	4.1
exch. Na "	0.5	0.5	0.5	0.6	0.6	0.7
exch. K "	1.0	1.0	1.4	1.0	0.6	0.9
CEC NH_4OAc	23.3	22.6	21.3	20.4	22.2	23.2
Base sat. NH_4OAc %	59.9	61.9	76.5	73.0	64.4	66.4
Avail. P (Bray II) ppm	19.6	33.5	28.8	27.3	35.0	30.4
bulk density		0.79	1.08		0.98	
permeability cm/hr		24.9	5.2		6.2	
water retention %						
pF 0		101.8	106.2		108.0	
pF 2		58.1	62.1		87.2	
pF 2,5		50.5	55.1		53.2	
pF 4,2		31.4	31.9		33.1	
available water %		19.1	23.2		20.1	

available water 0-100 cm : 157, 8 mm

KALI TLOGO SERIES

Pedon No. : KK 17 SYMBOL : TC

Classification : LPT-Bogor : Alluvial Eutrik
FAO : Eutric Fluvisol
Soil Taxonomy : Fluventic Eutropept, fine loamy, isohyperthermic

Location : 2,4 km NNW of Pudjon
Physiography : colluvial valleys with concave valley floors
Elevation : 1075 meter
Topography : concave 3-8% slope
Drainage : moderately well drained, mod. rapid permeability, slight risk of light flooding
Erosion : non; slight deposition
Vegetation : dryland agriculture: maize, onion, cabbage
Parent material: alluvial and colluvial sediments
Described by : W.H.Utomo, A.M.Prabowo and G.W.van Barneveld 2 December 1982

Ap (Ap) 00-22 cm : dark brown (10YR 3/3) moist; clay loam; medium, moderate granular to subangular blocky structure; friable, slightly sticky, slightly plastic; slightly acid; few, fine, faint Fe mottles; many fine roots; many fine, medium and coarse pores; clear, smooth boundary

A1 (A1) 22-48 cm : dark grayish brown (10YR 4/2) moist; loam with 15% scoria and pumice gravels, < 1 cm Ø ; medium, moderate angular blocky structure; friable, slightly sticky, slightly plastic; very slightly acid; few fine roots; many fine, common medium and few coarse pores; clear, wavy boundary

IIB (2B) 48-59 cm : dark brown (10YR 3/3) moist; loam; medium very weak angular blocky structure; friable, non sticky, non plastic; very slightly acid; few fine roots; many fine, medium and coarse pores; clear, wavy boundary

IIIB(3 B) 59-76 cm : very dark grayish brown (10YR 3/2) moist; loam with 5% scoria gravel < 1 cm Ø ; medium, moderate angular blocky structure; friable, slightly sticky, slightly plastic; very slightly acid; few fine roots; clear, wavy boundary

IVB (4B) 76-90 cm : dark brown (10YR 3/3) moist; loam; medium, moderate angular blocky structure; friable, sticky, plastic; very slightly acid; few fine roots; common fine, few medium and coarse pores; clear, wavy boundary

VB (5B) 90-118 cm : dark yellowish brown (10YR 4/4) moist; loam with 2,5 % andesitic gravel 2-5 cm Ø; medium, moderate angular blocky structure; friable, slightly sticky, slightly plastic; very slightly acid; clear, wavy boundary

ANALYTICAL DATA

Kali Tlogo series

Horizon Depth (cm)	Ap 00-22	A1 22-48	IIB 48-59	IIIB 59-76	VB 90-118	VIB 118-145
total clay %	34	27	21	27	25	25
total silt %	48	35	39	45	40	39
total sand %	18	38	40	28	35	36
very fine sand %	7	6	8	7	8	8
fine sand %	6	13	14	8	12	10
medium sand %	4	13	13	8	9	10
coarse sand %	1	4	4	4	4	6
very coarse sand %	tr	2	1	1	2	2
organic C %	3.3	2.0	2.0	2.3	1.5	1.0
total N %	0.33	0.20	0.24	0.25	0.17	0.13
C/N	10	10	8	9	8	10
pH (H_2O)	5.7	6.5	6.2	6.3	6.3	6.3
pH (KCl)	4.8	4.8	5.7	5.0	5.1	4.9
exch. Ca meq/100 grs	8.9	8.9	11.0	11.7	9.0	11.5
exch. Mg "	0.1	3.1	0.4	2.8	3.3	3.2
exch. Na "	0.5	0.4	0.6	0.5	0.6	0.8
exch. K "	0.5	0.4	0.5	0.4	1.0	1.0
CEC NH_4OAc "	32.0	21.1	20.8	19.2	18.0	18.0
Base sat. NH_4OAc %	31	61	60	80	77	92
Avail. P ppm (Bray II)	43.0	14.0	10.0	13.0	21.0	15.0

KAUMREJO SERIES

Pedon No. : KK 30 SYMBOL : K

Classification : LPT-Bogor : Eutric Cambisol
FAO : Eutric Cambisol
Soil Taxonomy : Andic Eutropept

Location : 3 km N of Selorejo damsite (foothills Luksongo range, W of lake)
Physiography : colluvial footslopes
Elevation : 725 meter
Topography : concave footslope, 12%
Drainage : well drained; moderate run-off; moderate permeability
Erosion : slight rill erosion
Vegetation : coffee and Leucaena glauca plantation
Parent material: colluvial material derived from ash and andesite
Described by : A.M.Prabowo, L. Rayes, Sudarto and G.W.van Barneveld
20 May 1983

A1 (A1) 00-16 cm : very dark grayish brown (10YR 3/2) moist; sandy clay loam with very few fine andesitic gravels < 2 cm Ø ; medium, moderate granular and subangular blocky structure; friable, slightly sticky, slightly plastic; very slightly acid; many fine and medium roots; many fine, medium and coarse pores; clear smooth wavy boundary

A1b (A2b) 16-35 cm : black (10YR 2/1) moist; clay loam with few fine andesitic gravels < 0,5 cm Ø; medium, moderate granular and subangular blocky structure; friable, slightly sticky, slightly plastic; neutral; common fine roots; many fine, medium and coarse pores; clear smooth to wavy boundary

B1 (BA) 35-48 cm : very dark grayish brown (10YR 3/2) moist; clay loam with few fine andesitic gravels < 0,5 cm Ø ; medium, moderate subangular blocky structure; friable, slightly sticky, slightly plastic; neutral; few fine roots; common fine, medium and coarse pores; clear smooth boundary

B21 (B1w) 48-77 cm : dark brown (10YR 3/3) moist; clay loam with 5% weathering tuff and gravels < 2 cm Ø ; medium, moderate subangular and angular blocky structure; friable, slightly sticky, slightly plastic; neutral; few fine roots; common fine, medium and coarse pores; clear smooth boundary

B22 (B2w) 77-104 cm : brown (10YR 4/3) moist; clay loam with 5% andesitic gravels < 3 cm Ø ; medium, moderate subangular and angular blocky structure; friable, slightly sticky, slightly plastic; neutral; few fine roots; common fine, medium and coarse pores; clear smooth boundary

B 3(BC) 104-133 cm : brown (10YR 4/3) moist; clay loam with 30% andesitic gravels < 3 cm Ø; medium, moderate angular blocky structure; friable, slightly sticky, slightly plastic; neutral; few fine roots; common fine, medium and coarse pores.

ANALYTICAL DATA Kaumredjo series

Horizon / Depth (cm)	A1 00-16	A1b 16-35	B1 35-48	B21 48-77	B22 77-104	B3 104-133
total clay %	25	27	27	27	31	36
total silt %	21	30	34	29	37	36
total sand %	54	43	39	44	32	28
very fine sand %	6	5	6	7	5	5
fine sand %	13	13	14	14	11	10
medium sand %	18	14	12	14	9	8
coarse sand %	13	9	6	7	5	3
very coarse sand %	4	2	1	2	2	2
organic C %	1.5	1.6	1.6	0.5	0.4	0.3
total N %	0.22	0.21	0.21	0.10	0.08	0.08
C/N	7	8	8	5	5	4
pH (H_2O)	6.4	6.7	6.8	6.9	6.8	6.9
pH (KCl)	5.6	5.0	5.0	4.9	4.8	4.8
pH (NaF)	9.7	9.7	9.5	9.5	9.5	9.7
exch. Ca meq/100 grs	8.7	11.6	18.6	12.6	10.1	11.7
exch. Mg "	4.0	5.3	9.0	6.5	6.5	9.4
exch. Na "	0.9	0.4	0.7	0.6	0.6	0.6
exch. K "	tr	0.8	1.5	1.3	1.6	1.6
CEC NH_4OAc "	27.6	25.1	36.8	25.9	28.5	28.8
Base sat. NH_4OAc %	49	72	81	81	66	81
Avail. P ppm (Bray II)	7	9	10	7	8	4

KRAANTJE LEK SERIES

Pedon No. : KK 1 SYMBOL : L

Classification : LPT Bogor : Andic* Cambisol
FAO : Andic* Cambisol
Soil Taxonomy : Andic Humitropept
medial isothermic family

Location : "Kraantje Lek"Damar plantation; 150 m SE of fieldshed
Physiography : Upper terrace
Elevation : 1170 meter
Topography : gently sloping; 4% convex slope
Drainage : well drained; slow to medium run-off; moderately rapid permeability
Erosion : slightly eroded (sheet)
Vegetation : Damar plantation (Agathis) with undergrowth of Pennisetum purpureum
Parent material: volcanic ash
Described by : M.Prabowo and G.W.van Barneveld
24 September 1981

Ap (Ap) 00-18 cm : black (10YR 2/1) moist and dark grayish brown (10YR 4/2) dry; loam on handfeeling with some pseudosand particles; medium, weak granular and subangular blocky structure; very friable, non sticky, non plastic; slightly acid; many fine, medium and coarse roots; many fine and medium pores; gradual and smooth boundary

A1 (A1) 18-29 cm : very dark brown (10YR 2/2) moist and dark garyish brown (10YR 4/2) dry; loam on handfeeling with some pseudosand; medium, weak to moderate granular and subangular blocky structure; very friable, non sticky, non plastic; slightly acid; many fine and medium roots; many fine and medium pores; clear and wavy boundary

A3 (AB) 29-39 cm : dark yellowish brown (10YR 3/4) moist; loam on handfeeling; medium, moderate subangular blocky structure; friable, non sticky, non plastic; very slightly acid; common fine roots; many fine and common medium pores; clear and smooth boundary

B1 (BA) 39-51 cm : dark brown (7,5YR 3/4) moist; loam on handfeeling with some pseudosand, tuff particles and pumice gravel up to 1 cm Ø; medium, moderate angular blocky structure; friable, slightly sticky, non plastic; very slightly acid; few fine roots; common fine and medium pores; clear and smooth boundary

B21 (Bw1) 51-75 cm : dark brown (7,5YR 3/4) moist; loam to clay loam on hand feeling with some semi-cemented ash nodules; very weak medium prisms breaking into medium moderate angular blocky structure; friable, slightly sticky and slightly plastic; some traces of very fine cutans on ped faces; very few fine roots; common fine and medium pores; clear and wavy boundary

B22 (Bw2) 75-105 cm : dark brown (7,5YR 3/4) moist; clay loam on handfeeling with some semi-cemented ash nodules; weak medium prisms breaking into medium moderate angular blocky structure; friable, slightly sticky and slightly plastic;very slightly acid; traces of cutans on ped faces; very few fine roots; common fine and medium pores; clear and smooth boundary

ANALYTICAL DATA

Kraantje Lek Series

Horizon	A1	A3/B1	B21	B22	B23	IIB
Depth	00-25	29-51	51-75	75-105	105-130	130+
Texture	Soil does not disperse well and particle size analysis was not made; see field estimates					
Organic C %	5.17	3.16	1.62	1.31	1.23	1.00
Total N %	0.43	0.28	0.18	0.14	0.13	0.11
C/N	12	11	9	9	9	9
pH (H_2O)	5.9	6.0	6.1	6.0	6.5	6.4
pH (KCl)	5.1	5.2	5.1	5.1	5.3	5.3
exch. Ca meq/100 grs	8.3	6.4	11.7	11.5	11.3	11.3
exch. Mg meq/100 grs	2.3	2.0	3.9	5.6	6.9	6.9
exch. Na meq/100 grs	0.5	0.4	1.1	1.4	1.6	2.1
exch. K meq/100 grs	0.6	0.9	1.6	1.8	0.4	0.4
exch. acidity (pH 7)	0.2	0.4	0.4	0.2	0.2	0.2
exch. acidity (pH 8.2)	29.6	27.4	23.8	15.8	23.4	22.2
CEC NH_4OAc meq/100 grs	28.0	24.0	33.8	30.2	33.2	34.6
CEC effective "	11.9	10.1	18.9	20.5	20.4	20.9
CEC sum of cations	41.3	37.1	42.1	36.1	43.6	42.9
Base sat. NH_4OAc %	41.8	40.4	54.7	67.2	60.8	59.8
Base sat. effective %	98	96	98	99	99	99
Base sat. sum cations %	28.3	26.1	43.5	56.2	46.3	48.3
Avail. P ppm (Bray II)	41.2	39.6	23.5	35.0	27.4	33.5
P-retention %	55.5	57.5	72.5	78.0	71.5	67.0
pH (NaF)	10.3	9.7	9.7	9.6	9.6	9.9
Variable charge %	71.1	72.7	55.1	43.2	53.2	51.2
bulk density	0.66	0.76	0.54	0.66		
liquid limit	62.0	66.4	111.7			
plastic limit	-	53.7	89.0			
plasticity index	-	12.7	22.7			
permeability cm/hr	7.1	8.5	5.3	7.8		
water retention %						
pF 0	106.3	114.9	168.9	175.1		
pF 2	63.9	62.2	103.0	109.1		
pF 2,5	41.2	48.9	91.4	86.7		
pF 4,2	28.7	26.9	41.9	43.7		

NGANTANG SERIES

Pedon No. : KK 40 SYMBOL : NA

Classification : PPT-Bogor :Mollic Mediteran
FAO :Luvic Phaeozem
Soil Taxonomy :Typic Argiudoll
clayey isohyperthermic

Location : 900 meter E of Desa Ngantang
Physiography : lower intervolcanic plain
Elevation : 680 meter
Topography : gently sloping (5-8%)
Drainage : well drained; slow run-off; rapid permeability
Erosion : none
Vegetation : kebun: coffee, banana, vanilla, coconut, cocoyam, pineapple, clove, durian, nangka
Parent material: volcanic ash
Described by : M.Prabowo, L. Rayes and G.W.van Barneveld
10 June 1983

A1 (A) 00-22 cm : very dark brown (10YR 2/2) moist; clay loam with few fine pumice particles; medium, moderate granular and subangular blocky structure; friable, slightly sticky and slightly plastic; very slightly acid; many fine and medium roots; many fine, medium and coarse pores; clear, smooth boundary

A3 (AB) 22-36 cm : very dark grayish brown to very dark brown (10YR 2,5/2) moist; clay loam with few fine pumice particles; medium, moderate subangular blocky structure; friable, sticky and plastic; very slightly acid; many fine and medium roots; many fine, medium and coarse pores; clear smooth boundary

B21 (B1w) 36-55 cm : very dark grayish brown to very dark brown (10YR 2,5/2) moist; clay with fine pumice tuff particles; medium, moderate angular blocky to weak prismatic structure; sticky and plastic; slightly acid; few patchy cutans on ped faces; common fine and medium roots; common fine, medium and coarse pores; clear, smooth boundary

B22 (B2w) 55-73 cm : dark brown to dark yellowish brown (10YR 3/3,5) moist; moist; clay with some fine pumice particles (3%); medium moderate angular blocky structure; sticky and plastic; very slightly acid; few fine roots; common fine, medium and coarse pores; clear smooth boundary

B23 (B3w) 73+-(128)cm : very dark grayish brown to very dark brown (10YR 2,5/2) moist; clay; medium, moderate angular blocky to weak prismatic structure; sticky and plastic; very slightly acid; few patchy cutans on ped faces; very few fine roots; common fine, medium and coarse pores

ANALYTICAL DATA

Ngantang series

Horizon Depth (cm)	A1 00-22	A3 22-36	B21 36-55	B22 55-73	B23 73-128
total clay %	33	35	45	42	53
total silt %	25	25	26	23	33
total sand %	42	40	29	35	14
very fine sand %	5	8	6	7	5
fine sand %	17	15	11	16	5
medium sand %	15	12	9	9	3
coarse sand %	4	4	2	2	1
very coarse sand %	1	1	1	1	-
organic c %	0.8	0.4	0.5	0.4	0.3
total N %	0.09	0.07	0.06	0.06	0.05
C/N	9	6	8	7	6
pH (H_2O)	6.4	6.1	5.9	6.3	6.2
pH (KCl)	4.9	4.8	4.7	4.7	4.7
exch. Ca meq/100 grs	9.0	15.6	13.7	21.0	20.7
exch. Mg "	4.2	2.5	5.4	5.5	6.8
exch. Na "	0.4	0.4	1.0	1.1	1.4
exch. K "	0.5	0.5	0.6	0.5	1.6
CEC NH_4OAc "	16.6	20.2	22.8	36.0	36.7
Base sat. NH_4OAc %	85.0	94.0	91.0	78.0	83.0
Avail.P ppm (Bray II)	5.0	4.0	5.0	56.0	10.0
pH (NaF)	9.6	9.6	9.7	9.6	9.7
bulk density	1.08	1.15	1.15		

NGANTRU SERIES

Pedon No. : KK 24 SYMBOL : G

Classification : PPT-Bogor : Mollic Andic* Cambisol
FAO : Andic* Phaeozem
Soil Taxonomy : Andic* Hapludoll, coarse loamy isohyperthermic

Location : 650 m NW of Desa Ngantru
Physiography : lower intervolcanic plain
Elevation : 700 meter
Topography : very gently sloping 3-5%
Drainage : well drained
Erosion : none
Vegetation : kebun: banana, maize, cassava, some coffee, coconut, some clove, kapok, red pepper
Described by : M.Prabowo, L. Rayes, G.W.van Barneveld and G. Cosijn 5 March 1983

Ap (Ap) 00-20 cm : dark brown (10YR 3/3) moist; coarse sandy loam with 15% pumice gravel < 1,5 cm ; medium, moderate granular and subangular blocky structure; friable, non sticky and non plastic; slightly acid; many fine roots; many fine, medium and common coarse pores; clear, smooth boundary

A1 (A1) 20-24 cm : yellowish brown and dark brown (10YR 5/6, 10YR 3/3) moist; coarse sandy loam with 70% pumice gravel < 4 cm Ø ; loose; friable, non sticky and non plastic; very slightly acid; few fine roots; many fine, medium and coarse pores; abrupt, smooth boundary

IIA1(2A) 24-44 cm : very dark brown (10YR 2/2) moist; sandy loam with 1% pumice gravel < 1 cm Ø; some charcoal and brick fragments; medium, moderate to weak subangular blocky structure; friable, slightly sticky and slightly plastic; very slightly acid; few fine roots; many fine, medium and coarse pores; clear wavy boundary

IIA3 (2AB) 44-60 cm : dark yellowish brown (10YR 3/6) moist; sandy loam with 1% pumice gravel < 0,5 cm Ø ; medium, weak subangular blocky structure; friable, slightly sticky, slightly plastic; very slightly acid; few fine roots; many fine, common medium and few coarse pores; clear smooth boundary

IIB21(2B1w) 60-78 cm : yellowish brown (10YR 5/6) moist; coarse sandy loam with 5% pumice gravel < 1 cm Ø ;medium weak angular to subangular blocky structure; friable, slightly sticky and slightly plastic; very slightly acid; few fine roots; common fine and medium and few coarse pores; clear smooth boundary

IIB22(2B2w) 78-106 cm : dark yellowish brown (10YR 4/4) moist; coarse sandy loam with 25% pumice gravel < 3 cm Ø ; medium, weak angular blocky structure; friable, non sticky and non plastic; very slightly acid; few fine roots; common fine, and medium and few coarse pores; clear smooth boundary

IIIA11(3A1) 106-139 cm : dark brown (10YR 3/3) moist; sandy loam with 5% pumice gravel < 2 cm Ø ; medium, moderate angular blocky structure; friable, slightly sticky and slightly plastic; neutral; few fine roots; many fine, medium and coarse pores; clear smooth boundary

ANALYTICAL DATA Ngantru series

Horizon Depth (cm)	Ap 00-20	IIA1 24-44	IIA3 44-60	IIB21 60-78	IIB22 78-106	IIIA12 140-150
total clay %	17	13	13	8	9	16
total silt %	23	33	31	28	20	21
total sand %	60	54	56	64	71	63
very fine sand %	6	7	7	6	6	6
fine sand %	9	11	10	12	12	14
medium sand %	19	16	17	20	26	21
coarse sand %	20	15	16	19	21	16
very coarse sand %	6	6	6	7	7	6
organik C %	1.2	1.6	1.4	0.9	0.7	0.9
total N %	0.10	0.12	0.13	0.08	0.07	0.05
C/N	12	13	11	11	10	18
pH (H_2O)	6.0	6.3	6.4	6.5	6.5	6.7
pH (KCl)	4.9	5.0	5.0	5.2	5.2	5.0
exch. Ca meq/100 grs	4.0	4.6	4.6	4.3	4.8	5.4
exch. Mg "	1.9	3.2	3.5	2.6	1.3	1.2
exch. Na "	0.3	0.4	0.4	0.3	0.3	0.4
exch. K "	0.8	1.2	0.8	0.4	0.3	0.6
CEC NH_4OAc "	10.7	15.9	16.5	9.4	12.9	14.3
Base sat. NH_4OAc %	69	59	56	81	52	53
Avail. P ppm (Bray II)	115	28	18	16	15	25
pH (NaF0	10.6	10.9	10.9	10.9	10.9	10.8
bulk density	1.03	0.85		0.94		

NGEBRONG SERIES

Pedon No. : KK 28 SYMBOL : N

Classification : LPT-Bogor : Mollic Andosol
FAO : Mollic Andosol
Soil Taxonomy : Udic Eutrandept, medial, isothermic

Location : 3,6 km SW of Ngebrong
Physiography : steep hillslopes Anjasmoro range
Elevation : 1050 meter
Topography : 8-12% convex crest; side slopes 60-70%
Drainage : well drained, moderate run-off; moderate permeability
Erosion : slight sheet erosion
Vegetation : kirinyu with grass undergrowth
Parent material: volcanic ash
Described by : Sudarto, L. Rayes and G.W. van Barneveld 20 May 1983

A11 (A1) 00-07 cm : very dark brown (10YR 2/2)moist; sandy clay loam on handfeeling; medium, moderate granular and subangular blocky structure; friable, slightly sticky, slightly plastic; very slightly acid; many fine roots; many fine, medium and coarse pores; clear smooth boundary

A12 (A2) 07-15 cm : very dark brown (10YR 2/2) moist; loam to clay loam on handfeeling; medium, moderate granular and subangular blocky structure; friable, slightly sticky, slightly plastic; very slightly acid; many fine roots; many fine, medium and coarse pores; clear smooth boundary

A 3(AB) 15-35 cm : very dark brown (10YR 2,5/2) moist; clay loam to sandy clay loam on handfeeling; medium, moderate granular and subangular blocky structure; friable, slightly sticky and slightly plastic; very slightly acid; many fine roots; many fine and common medium pores; clear smooth boundary

II A11(2A1): 35-52 cm : very dark brown (10YR 2/2) moist; sandy clay loam on handfeeling with approx. 1% andesitic gravels < 0,5 cm Ø; medium, moderate angular blocky structure; friable, slightly sticky, slightly plastic; very slightly acid; many fine roots; common fine and medium pores; clear, smooth boundary

IIA12(2A2) 52-85 cm : very dark brown (10YR 2/2) moist; loam to sandy clay loam on handfeeling; medium, moderate subangular and angular blocky structure; friable, slightly sticky,slightly plastic; very slightly acid; common fine roots; common fine and medium pores; clear, smooth boundary

IIB (2B) 85-120 cm : dark brown 910YR 3/3) moist; sandy loam on handfeeling with 55% pumice gravels < 3 cm Ø ; weak angular blocky structure; friable, slightly sticky, slightly plastic; neutral; abrupt smooth boundary

IIIB(3B) 120-140 cm : brown (10YR 4/3) moist; sandy clay loam to clay loam on handfeeling; medium, moderate angular blocky structure; friable, slightly sticky, slightly plastic; neutral; few fine roots; common fine and medium pores

ANALYTICAL DATA Ngebrong series

Horizon	A1	A3	IIA11	IIA12	IIB	III
Depth (cm)	00-15	15-35	35-52	52-85	85-120	120-140
texture	Soil does not disperse well and particle size analysis was not made. See field estimates					
organic C %	4.3	1.8	2.5	2.4	1.3	0.7
total N %	0.48	0.17	0.26	0.22	0.16	0.10
C/N	9	11	10	11	8	7
pH (H_2O)	6.5	6.0	6.3	6.2	6.7	6.6
pH (KCl)	5.2	4.7	4.8	4.8	4.8	4.9
pH (NaF)	10.2	10.5	10.5	10.6	10.5	10.2
exch. Ca meq/100 grs	18.2	13.0	10.2	12.9	10.9	10.7
exch. Mg "	3.5	8.7	11.5	10.2	10.1	7.3
exch. Na "	1.1	0.6	0.3	0.3	0.4	0.6
exch. K "	0.1	0.4	-	0.1	0.1	0.1
CEC NH_4OAc "	27.4	39.2	31.1	37.4	33.1	29.5
Base sat. NH_4OAc %	84	58	71	63	65	63
Avail. P ppm (Bray II)	6	6	4	4	4	6
P-retention %	83	96	84	84	86	94

PUDJON SERIES

Pedon No. : KK 7 SYMBOL : P

Classification : LPT-Bogor : Anthropic* Eutric Cambisol
FAO : Anthropic* Eutric Cambisol
Soil Taxonomy : Anthropic* Andic Eutropept medial isothermic family

Location : 500 m East of Bendosari village
Physiography : middle terrace
Elevation : 1115 meter
Topography : sloping (13% single slope); terraced
Drainage : well drained; medium run-off; moderately slow permeability
Erosion : slightly eroded
Landuse : rainfed foodcrop cultivation with some additional irrigation (maize, vegetables and in the past also some rice)
Parent material: mixture of ash and colluvial material derived from ash and tuff; terraced land with considerable cut and fill
Described by : M.Prabowo, L.Rayes and G.W.van Barneveld 5 October 1981

Ap (Ap) 00-14 cm : very dark brown (10YR 2/2) moist and very dark grayish brown (10YR 3/2) dry; loam; medium moderate angular and subangular blocky structure; friable, slightly sticky and slightly plastic; slightly acid; common fine roots; very porous; clear and smooth boundary

B1 (BA) 14-29 cm : very dark brown (10YR 2/2) moist; loam; medium very weak prisms breaking into medium moderate blocky structure; slightly firm, sticky and plastic; very slightly acid; common fine FeMn concretions; few fine faint Fe mottles; few fine cutans on ped faces; few fine roots; few medium and very few fine pores; clear smooth boundary

B2 (Bw) 29-46 cm : very dark brown (10YR 2/2) moist; clay loam on handfeeling locally with some rounded andesitic stones max.5 cm Ø and tuff; medium weak prisms breaking into medium moderate angular blocky structure; friable, sticky and plastic; very slightly acid; few fine FeMn concretions and few fine faint Fe mottles; common fine cutans on ped faces; very few fine roots; common fine and medium pores; clear and irregular boundary

IIIA (3A) 46-56 cm : black to very dark brown (10YR 2/1,5); sandy loam; medium, moderate to weak angular to subangular blocky structure; friable, non sticky, non plastic; very slightly acid; very few fine roots; many fine and medium pores; clear and smooth boundary

IIIB (3 Bw): 56-83 cm : very dark brown (10YR 2/2) moist; clay loam on handfeeling; medium weak prisms breaking into medium moderate angular blocky structure; friable, sticky and plastic;very slightly acid; few fine cutans on ped faces; very few fine roots; common fine and medium pores; gradual smooth boundary

IVB (4 Bw) 83-116 cm : dark brown (10YR 3/3) moist; clay loam on handfeeling. with 5% semi weathered tuff particles and nodules 0,5 cm Ø and few 5-10 cm Ø rounded andesitic stones; medium weak prisms breaking in medium moderate angular blocky structure; friable, sticky and plastic; very slightly acid; few fine cutans on ped faces; very few fine roots; common fine and medium pores; gradual smooth boundary

ANALYTICAL DATA

Pudjon Series

Horizon Depth (cm)	Ap 00-14	B1 14-29	B2 29-38	IIIA 46-56	IIIB 56-83	IVB1 83-116
total clay %	25.9	23.8	11.8x	3.9x	18.9x	8.4x
total silt %	47.8	48.5	67.0	46.9	50.7	65.2
total sand %	26.3	27.7	21.2	49.1	30.4	26.4
very fine sand %	4.6	5.1	0.4	9.1	6.1	5.1
fine sand %	12.5	13.0	13.3	22.0	14.0	13.7
medium sand %	7.4	7.5	6.1	15.9	8.1	6.1
coarse sand %	1.6	2.0	1.1	2.1	2.0	1.1
very coarse sand %	0.2	0.3	0.4	0.1	0.2	0.3
organic C %	2.08	1.93	2.39	2.89	2.55	1.47
total N %	0.14	0.12	0.13	0.20	0.19	0.10
C/N	15	16	18	14	13	15
pH (H_2O)	5.7	6.0	6.1	6.3	6.2	6.2
pH (KCl)	4.0	5.0	4.2	5.0	4.9	4.8
exch. Ca meq/100 grs	8.2	8.7	8.7	8.8	9.0	9.0
exch. Mg meq/100 grs	3.2	4.7	4.4	3.0	2.7	2.6
exch. Na "	0.5	0.6	0.6	0.7	0.6	0.8
exch. K "	1.2	1.2	1.2	2.0	1.2	1.1
CEC NH_4OAc "	22.6	23.4	22.8	24.6	21.0	21.4
Base sat NH_4OAc %	57.9	64.9	65.3	58.9	64.3	63.1
available P (Bray II)	18.1	16.5	15.0	21.2	18.1	19.6
bulk density	1.13		1.15	1.16		
permeability cm/hr	6.1	3.8	1.75	1.0		
liquid limit	49.5		46.7	45.5		56.7
plastic limit	40.0		42.4	32.8		44.2
plasticity index	9.5		4.3	12.7		12.5
pF 0 water %	79.3		80.0	99.8		
pF 2 "	41.7		44.2	53.5		
pF 2,5 "	37.8		37.8	48.7		
pF 4,2 "	30.8		30.1	34.2		

x samples B2, IIIA, IIIB and IVB did not disperse well and the clay contents should be higher than indicated; see field estimates

SEBALUH SERIES.

Pedon No. : KK 23 SYMBOL : B

Classification : PPT-Bogor : Eutric Cambisol
FAO : Eutric Cambisol
Soil Taxonomy : Anthropic* Andic Humitropept
fine silty, isohyperthermic

Location : 1,2 km WSW from Desa Sebaluh
Physiography : colluvial footslopes
Elevation : 1210 meter
Topography : sloping; 8-12 % concave slope
Drainage : well drained; medium run-off; medium permeability
Erosion : slight gully erosion between terraced fields
Vegetation : maize, vegetables
Parent material: colluvial materials derived from volcanic ash
Described by : M.Prabowo, L.Rayes and G.W.van Barneveld
3 March 1983

Ap (Ap) 00-18 cm : very dark brown (10YR 2/2) moist; clay loam; medium, moderate granular and subangular blocky structure; friable, slightly sticky and slightly plastic; acid; many fine roots; many fine, medium and coarse pores; few, fine charcoal fragments; clear, smooth boundary

A1 (A1) 18-33 cm : dark brown (7,5YR 3/2) and very dark brown (10YR 2/2) moist; clay loam; medium, moderate granular and subangular blocky structure; friable; slightly sticky and slightly plastic; slightly acid; common fine roots; many fine, medium and coarse pores; clear wavy boundary

B1 (BA) 33-46 cm : dark yellowish brown (10YR 3/4) to dark brown (7,5YR 3/4) moist; clay loam with very few, fine tuff particles < 2mm Ø ; medium, moderate subangular blocky structure; friable, slightly sticky, slightly plastic; very slightly acid; few, patchy cutans on ped faces; few fine roots; common fine and medium pores; clear smooth boundary

B21 (B1w) 46-98 cm : dark yellowish brown (10YR 3/4) moist; clay loam with few fine tuff particles < 2 mm Ø ; medium, moderate angular blocky structure; friable, sticky and plastic;very slightly acid; few, fine cutans on ped faces; few fine roots; common fine, medium and coarse pores; diffuse smooth boundary

B22 (B2w) 98-150 cm : dark brown (7,5 YR 3/4) moist; clay loam on handfeeling with few, fine tuff particles < 2 mm Ø ; medium, moderate angular blocky structur; friable, sticky and plastic; neutral; traces of cutans on ped faces; very few fine roots; common fine and medium and many coarse pores; clear to abrupt and smooth boundary

B3 (BC) 150 + : brown to dark brown (7,5YR 4/4) moist; clay loam on hand-feeling with common, fine tuff 3 mm Ø ; medium, moderate angular blocky structure; friable, slightly sticky and slightly plastic; very slightly acid; very few fine roots; many fine and coarse and few medium roots pores

ANALYTICAL DATA Sebaluh series

Horizon Depth (cm)	Ap 00-18	A1 18-33	B1 33-46	B21 50-90	B22 100-150	B3 150-170
total clay %	31	34	37	30	24 *	14 *
total silt %	40	36	37	41	39	37
total sand %	29	30	26	29	37	49
very fine sand %	17	18	17	18	20	20
fine sand %	9	9	7	8	11	16
coarse sand %	3	3	2	3	5	11
very coarse sand %	tr	tr	tr	tr	1	2
organic C %	2.80	2.40	1.10	1.00	0.80	1.20
total N %	0.23	0.17	0.10	0.08	0.07	0.13
C/N	12	14	11	13	11	9
pH (H_2O)	5.5	5.8	6.5	6.5	6.6	6.2
pH (KCl)	4.2	4.1	4.6	4.9	5.0	5.4
exch. Ca meq/100 grs	8.5	9.0	10.6	11.3	12.6	14.5
exch. Mg "	1.8	2.7	6.0	5.5	4.6	7.8
exch. Na "	0.4	0.4	0.6	0.7	0.8	0.9
exch. K "	1.0	0.4	0.9	0.5	0.4	0.5
CEC NH_4OAc "	30.8	28.9	30.8	23.0	23.3	37.6
Base sat. NH_4OAc %	38.0	43.0	59.0	78.0	79.0	63.0
Avail. P ppm (Bray II)	33.0	16.0	8.0	10.0	9.0	12.0
pH (NaF)	10.1	10.1	10.2	10.1	10.1	10.5

* samples B22 and B3 did not disperse well and clay contents should be higher than indicated; see field estimates

SELOREJO SERIES

Pedon No. : KK 41 SYMBOL : S

Classification : PPT-Bogor : Anthraquic* Mollic Mediteran
FAO : Anthraquic* Luvisol
Soil Taxonomy : Anthraquic* Tropudalf, clayey, isohyperthermic

Location : 700 m NE of Desa Ngantru
Physiography : Lower intervolcanic plain
Elevation : 720 meter
Topography : gently sloping (5-8%)
Drainage : imperfectly drained; slow run-off; slow permeability
Erosion : none
Vegetation : wetland rice
Parent material: ash and pumice of Gunung Kelud
Described by : M.Prabowo, L. Rayes and G.W.van Barneveld
10 June 1983

Ap (Ap) 00-12 cm : dark gray to very dark gray (10YR 3,5/1) moist; sandy clay loam on handfeeling with 2% fine pumice gravels < 3 cm Ø ; medium ,moderate subangular and angular blocky structure; firm, slightly sticky and slightly plastic; slightly acid; common fine, distinct Fe mottles; many fine roots; common fine and medium and few coarse pores; clear smooth boundary

A12 (A2) 12-22 cm : dark gray to dark grayish brown (10YR 4/1,5) moist; sandy clay loam on handfeeling with 5% fine pumice gravel < 3 cm Ø; medium, moderate angular blocky sturcture; firm, slightly sticky and slightly plastic; neutral; common, fine, distinct Fe mottles; many fine roots; common fine and medium and few coarse pores; abrupt smooth boundary

B1 (BA) 22-28 cm : dark gray to dark grayish brown (10YR 4/1,5) moist; sandy clay on handfeeling with 10% fine pumice gravel < 3 cm Ø; medium, strong angular blocky structure; slightly cemented traffic pan, firm, slightly sticky and slightly plastic; neutral; many, fine, distinct Fe mottles; few fine and medium and few coarse pores;abrupt smooth boundary

B21g(B1g) 28-57 cm : dark grayish brown (10YR 4/2) moist; sandy clay on handfeeling with 10% fine pumice gravels < 3 cm Ø; medium, strong angular blocky structure; firm, sticky and slightly plastic; neutral; common fine Mn concretions; many, medium, distinct FeMn mottles; few fine, medium and coarse pores; clear smooth boundary

B22g(B2g) 57-75 cm : dark gray to dark grayish brown (10YR 4/1,5) moist; clay on handfeeling with 5% fine pumice gravels < 3 cm ; medium, moderate angular blocky structure; firm,sticky and plastic; slightly acid; common, fine Mn concretions; many, medium distinct Mn mottles; few, fine, medium and coarse pores; abrupt and smooth boundary

B3 (BC) 75 cm + : hardpan

ANALYTICAL DATA Selorejo series

Horizon Depth (cm)	Ap 00-12	A12 12-22	B21 28-57	B22 57-75
total clay %	32	38	42	50
total silt %	16	15	13	12
total sand %	52	47	45	38
very fine sand %	8	8	6	4
fine sand %	10	11	8	7
medium sand %	12	10	12	10
coarse sand %	11	8	7	10
very coarse sand %	11	10	13	7
organik C %	0.8	0.6	0.4	0.4
total N %	0.15	0.11	0.06	0.06
C/N	5	5	7	7
pH (H_2O)	5.7	6.9	6.6	5.9
pH (KCl)	5.0	5.4	5.4	5.5
exch. Ca meq/100 grs	31.0	18.6	23.4	24.8
exch. Mg "	4.1	9.8	4.1	6.2
exch. Na "	0.5	0.5	1.1	1.1
exch. K "	tr	0.1	1.1	1.2
CEC NH_4OAc "	48.3	37.1	55.7	37.2
Base sat. NH_4OAc %	74	78	83	90
Avail. P ppm (Bray II)	29	25	35	44
pH (NaF)	9.7	9.8	10.0	9.9

TAWANGSARI SERIES

Pedon No. : KK 4 SYMBOL : T

Classification : LPT-Bogor : Anthraquic* Mollic Mediteran
FAO : Anthraquic* Luvic Phaeozem
Soil Taxonomy : Anthraquic * Argiudoll
fine clayey isohyperthermic family

Location : 400 m NW of entrance Bendosari village
Physiography : lower middle terrace
Elevation : 990 meter
Topography : gently sloping (4% single slope); terraced
Drainage : imperfectly drained (altered drainage); slow run-off; very slow permeability
Erosion : slight gully erosion between sawahs
Landuse : irrigated agriculture: maize, sweet potatoes, vegetables; in some years rice
Parent material: volcanic ash over andesitic tuff
Described by : M. Prabowo and G.W.van Barneveld
25 September 1981

Ap (Ap) 00-13 cm : very dark brown (10YR 2/2) moist; silty clay loam; medium moderate granular and subangular blocky structure; slightly firm, slightly sticky and slightly plastic; acid to slightly acid; few fine FeMn concretions; few fine faint Fe mottles; common fine roots; many fine and medium pores; clear and smooth boundary

A1 (A1) 13-23 cm : very dark brown (10YR 2/2) moist; silty clay loam; medium moderate angular blocky structure; slightly firm, slightly sticky and plastic; acid to slightly acid; common fine FeMn concretions; common fine distinct FeMn mottles; some organic matter coatings on ped faces; few fine roots; few fine pores; clear and smooth boundary

B1 (BA) 23-36 cm : very dark grayish brown (10YR 3/2) moist; clay loam; medium very weak prisms breaking into medium moderate angular blocky structure; slightly firm, sticky and plastic; slightly acid; few fine FeMn concretions; common fine distinct FeMn mottles; few fine cutans on ped faces; few fine pores; clear smooth boundary

B21 (B1t) 36-60 cm : very dark grayish brown (10YR 3/2) moist; clay loam; medium moderate prisms breaking into medium moderate angular blocky structure; slightly firm,sticky and plastic; very slightly acid; few fine FeMn concretions; common fine distinct Mn mottles; common fine cutans on ped faces; few fine pores; clear smooth boundary

B22 (B2t) 60-78 cm : very dark brown to very dark gray brown (10YR 2,5/2) moist; clay loam; medium weak prisms breaking into medium moderate angular blocky structure;firm, sticky and plastic; very slightly acid; very few fine Mn mottles and concretions; few fine cutans on ped faces; common fine pores; clear smooth boundary

IIB2 (2Bw) 78-119 cm : dark brown (10YR 3/3) moist; sandy clay derived from weathering tuff; medium and coarse angular blocky structure; friable, sticky and plastic; common medium pores; clear smooth boundary

ANALYTICAL DATA

Tawangsari series

Horizon Depth (cm)	A1 00-23	B1 23-36	B21 36-60	B22 60-78	IIB 78-119
total clay %	28.4	30.1	34.5	31.6	38.5
total silt %	60.9	43.0	23.8	28.2	11.1
very fine sand %	2.4	5.2	6.3	6.2	7.7
fine sand %	4.2	10.3	16.5	16.7	21.2
medium sand %	2.5	8.4	13.0	11.7	13.7
coarse sand %	1.4	2.5	4.9	4.3	5.6
very coarse sand %	0.2	0.5	0.9	1.3	2.2
organic C %	1.77	1.31	1.00	0.93	0.46
total N %	0.15	0.12	0.08	0.07	0.04
C/N	12	11	12	13	12
pH (H_2O)	5.5	5.9	6.2	6.4	5.8
pH (KCl)	4.8	5.4	5.0	5.4	5.4
exch. Ca meq/100 grs	9.2	10.2	10.8	12.5	11.5
exch. Mg "	5.9	6.6	6.5	6.6	6.5
exch. Na "	0.7	0.7	0.8	1.3	1.2
exch. K "	1.2	1.3	2.7	4.3	4.3
exch. acidity (pH 7)	0.10	0.20	0.30	0.35	0.40
extr. acidity (pH 8.2)	18.2	20.6	16.0	18.0	13.9
CEC NH_4OAc "	32.2	30.0	34.2	33.2	29.8
CEC effective"	17.1	19.0	21.1	25.0	23.9
CEC sum of cations	35.2	39.4	36.8	42.7	37.4
Base sat. NH_4OAc	52.8	62.6	60.8	74.4	78.8
Base sat. effective	99	98	98	98	98
Base sat. sum cations	48.2	47.7	56.5	57.8	62.8
Avail.P ppm (Bray II)	30.1	16.8	28.5	47.8	15.0
bulk density	1.22	1.17	1.38		1.01
liquid limit	47.5	49.4			83.6
plastic limit	40.6	37.4			66.9
plasticiky index	6.9	12.0			16.7
permeability cm/hr	11.3	0.16	0.06		1.1
pF 0 % water	86.4	83.2	71.9		125.9
pF 2 "	51.0	40.8	37.3		72.7
pF 2.5 "	39.0	37.4	35.3		67.9
pF 4.2 "	25.5	25.3	26.7		47.3

available water mm 0 - 100 cm : 119,5 mm