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SOIL UNITS DISTRIBUTION IN PESING WATERSHED BANTUL, YOGYAKARTA, INDONESIA

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ABSTRACT

The study was carried out in Pesing Watershed, which is situated in the Eastern region of Yogyakarta Province. This watershed is a sub-watershed of Opak River that has big variation of landforms. Therefore, it is suitable for the study of soil units distribution.

The objectives of this research are: (1) to study the landform characteristics and their distribution , (2) to study the soil characteristics and their distribution, and (3) to study the relationships between soil and landform units in the study area.

Geomorphological approach was applied to study the soil unit distribution in the study area. Landform units as geomorphological object were identified through aerial photo and topographic map interpretation. Field works as well as laboratory works were intended to check both the results of aerial photo and topographic map interpretations and soil unit identification.

The landform units in the study area vary due to morphology, lithology, genesis, morphochronology and morphoarrangement. These landform unit variations control soil units distribution in the study areas. Geomorphological processes have been modifying the landform unit in the different intensity from one to another. These geomorphological processes have been disturbing soil formation processes. Entisols and Inceptisols as well as Lithic sub group soils occur in the landform units with considerable high intensity of geomorphological processes. Alfisols, Verisols, Mollisols as well as non Lithic sub group soils occupy the landform units with low intensity of geomorphological processes.

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INTRODUCTION

Soil information is very important in land resources management. Several land utilization types such as agriculture, forestry, animal husbandry, etc. always involve soil resources information. Misuse of land may be initialized from lack of knowledge of soil properties. 'What should be planted on a certain types of soils ? What kind of management practice should be made?", are two examples of questions related to soil properties that always arise in land resources management. Those soil information may not only include physical, chemical, biological, and morphological characteristics but it should include the distribution of soils. Soil characteristics data in certain area is always linked to soils distribution. Any soil type or soil unit has its own soil characteristics. Therefore, information of soil distribution, which usually presented as soil map, is a vital data in land resources management (Dent and Young, 1980).

The process of soils data collection, which includes physical, chemical, biological, morphological characteristics and soils distribution is a tedious work when it is done through conventional method. Nowadays, the advance of remote sensing and geographic information system techniques give more possibility to characterize land surface information. Unfortunately, soils, which cover most of land surface, are more characterized by their internal morphology than their external ones. However, that internal morphology of soils is closely related to their external morphology that may be characterized using remote sensing and geographic information system techniques. Furthermore, van Wambeke and Forbes (1986) states that soils distribution over land surface is not in a random form but it is more systematic according to landform distribution.

The Pesing Watershed is a small sub-watershed of Opak River located in Yogyakarta, Indonesia. This watershed has great variation of lithological and morphological characteristics, which suitable for field research in natural science such as soil-geomorphology (Sartohadi, 1997). It is considered as critical watershed, which should be well managed to maintain it's from further land degradation. As other watershed in Indonesia, soil information of Pesing Watershed is very limited. Therefore, land resources management program may not successfully run. To overcome the main problem (i.e., lack of soil information) in land resources management of Pesing Watershed, this research has objectives as stated in the following sentences:

a) to study the landform characteristics and its distribution in the study area;
b) to study the soil characteristics and its distribution in the study area;
c) to study the relationships between soils and landforms of the study area.

THEORETICAL CONSIDERATION

The object of soil science and geomorphology are located on the earth surface. Soil science studies unconsolidated material that covers earth surface as a result of soil formation process (Gerard, 1992; Birkeland, 1999). Geomorphology characterized landform on the earth surface and emphasizes on their genesis, distribution and relationships to other aspects in environmental context (Verstappen, 1983). Some geomorphologist state that soil formation process is a part of geomorphological processes, which mainly related to internal morphological evolution of unconsolidated material on the earth surface. However, soil scientist may have different opinion because soil formation processes may not modify or only slightly modify the earth surface.

According to Jenny (1941), soil is a function of five soil formation factor, i.e. parent material, relief, climate, organism, and time. Soil parent material may derived from rock weathering of underlying parent rock or may come from other parent rocks located in another places. Those soil parent materials, later on, is modified by soil formation processes under strong influence of climate and organism. The final product of the act of that processes during the time of soil formation is soils, which have a certain chemical, physical, biological and morphological characteristics. The time of soil formation may hundreds years or even more than a thousand years. During those time spans, the location where the soil is formed may have modified due to geomorphological processes. Nevertheless, discussion of soil formation and geomorphological processes is similar with discussion of number and picture sides of coin (Daniels and Hammer, 1992; Gerrard 1992).

Landforms on the earth surface are product of geomorphological processes that work on specific parent rock during their time of formation. Geomorphological processes include endogenic, exogenic and extra terrestrial processes. Those of exogenic processes are strongly influenced by climate, topography/relief, and organism. Therefore, when the discussion of geomorphological processes is focused on exogenic processes, both soil and landform have similar factors of formation (Gerrard, 1992). Moreover, geomorphological and soil formation processes may not working simultaneously but in most cases they are working consecutively. Soil formation may not run in the areas of active geomorphological processes such as flood, inundation, any types of mass washing, erosion and sedimentation both by wind and water. Other thing that must be taken into account is soil parent material may not come from the underlying parent rock. In the case of transported soil parent materials, geomorphological process analysis may be useful to determine the source of those materials (Bennema and Gellens, 1969).

Soil is characterized mainly based on its internal morphology; therefore, soil unit identification has to be determined in the field. In another hand, landform that controls soil distribution may be characterized based on its external morphology. Knowledge of landform-soil relationships provides a possibility to apply remote sensing techniques to map soils distribution (Mulders, 1987; de Bruin et al., 1999). Remote Sensing technique may provide a synoptic view of land surface; therefore, landform units identification may be done accurately without much of field works.

Recent development of geographic information system techniques gives possibility to merge remote sensing data and map and present them in a perspective view on computer monitor (Schmidt and Dikau, 1999). Nevertheless, landforms identification may be done thoroughly and fast. However, these all advance techniques could not replace all field works, which required for soil unit identification. Soil mapping through geomorphological approach by applying remote sensing and geographic information system techniques may reduce the volume of field and laboratory works that also means reduce budged and time consumption (Sartohadi, 2001).

THE STUDY AREA

Pesing Watershed is one of three watersheds located in front of west escarpment of Gunungkidul Range. They are Ngijo Watershed located in the North, Celeng Watershed positioned in the South and Pesing Watershed located in the middle. Among the other watershed, Pesing Watershed is the smallest one. However, based on the physical geographic situation, Pesing Watershed has highest variation as others.

The Pesing River is controlled by normal fault and flows parallel to those fault line. It devides hilly area into two parts, west and east hilly areas. The one in the west of The Pesing River is footwall of the normal fault, while the east hilly area is part of hanging wall of normal fault that performs Baturagung Escarpment. Topographically, slopes of east hilly area are steeper than those in west. The slopes of west hilly area is parallel to its dip, therefore, it is named as back slope. Elevation of hills in Pesing Watershed ranges from 172 – 375 above mean sea level (msl).

Geologically, Pesing Watershed consists of two Tertiary Rocks formation i.e., Semilir and Nglanggeran Formation and two Quaternary Rocks, i.e., alluvium of Merapi Volcano and alluvium of Gunungkidul Range. Semilir Formation occupies the West Hilly area and it is order than Nglanggeran Formation that is located in the East Hilly area. Semilir Formation is dominated by bedded tuffaceous sandstone. Volcanic breccias are predominant in Nglanggeran Formation (Bronto dkk, 1999). Both Nglanggeran and Semilir Formation are volcanic rocks. All rocks member of Semilir Formation had been sedimented under seawater, while these of Nglanggeran Formation were partly continental facies.

Alluvium of Merapi Volcano is located in the area surrounding of Opak River and alluvium of Gunungkidul Range is doposited along Pesing River. In general, alluvium of Merapi Volcano consists of sand-gravel size of andesitic materials. Silt size materials cover some parts of alluvium of Merapi Volcano, mostly the lower part that nowadays for irrigated paddy field. Alluvium of Gunungkidul Range is relatively finer and has darker color than alluvium of Merapi Volcano. Recent landuse of that area is rain fed agricultural field.

Rainfall data recorded in Pleret, the study area is 2372 mm/year. Most of rains fall during the period of October – May, while the rest is dry season. The annual air temperature is 27.2°C. Those air temperature data is recorded at Adisucipto Airport (± 10 km NW of the study area). The lowest air temperature is recorded in September (26.8°C), while the highest is noted in May (28.3°C). The annual potential evapotranspiration estimated using Thornwait-Matter Method (van Dam, 1972) is 1826 mm. Based on the available meteorological data, the study area should have enough water. However, in fact the study area is lack of water during the dry period.

Agricultural field dominated recent landuse of Pesing Watershed. Irrigated agricultural field is mainly located in area surrounding Opak River, while rain red one is located in other areas. Rice is common during rainy season, while corn, cassava, chili and tobacco are usually planted during dry season. Settlements are usually located in foot slope areas. Coconut, jackfruit, bomboo are most common trees in settlement areas.

Physical and chemical rock weathering are the initial processes of soil parent material formation. They work intensively on bare rocks body and/or along cracks. Other geomorphological processes of soil erosion and many types of mass movement are still intensively working in Pesing Watershed, particularly in the hilly areas. Sedimentation of transported materials from upper slopes occurs in plain areas particularly along areas surrounding of Pesing River.

METHODS

This research was carried out through both laboratory and field work. The laboratory works were intended to interpret the aerial photos and maps as well as soil samples analysis. The aerial photos and maps interpretations were carried out prior the field checks and they were proposed to identify landform units in the study area. The field checks had two aims, are landform units checking and to identify soil units distribution. Geomorphological process analysis as well as soil unit identification were applied to identify the soil units distribution in the study area.

Those landform units identification that carried out based on aerial photo interpretation of false color infrared photos and topographic map interpretation is presented as geomorphological map. The scale of aerial photo is 1:30.000, while the scale of topographic maps are 1:25.000. Morphological analysis as well as morphodynamic and morphoarrangment were the fundamental analysis in aerial photo interpretation for landform unit delineation. The final results of aerial photo interpretation were transferred into topographic maps.

Soil samples in the field were determined based on stratified purposive aligned sampling using soil hand bore in order to get information of soil distribution. Landform unit was applied as stratum and transect of soil hand bore observation were made perpendicular to the direction of geomorphological process. The location of soil profile was determined based on soil distribution analysis. Those soil distribution analysis were carried out using soil hand auger data. Soil profile description was made according to Guide Line for Soil Profile Description from U.S. National Soil Survey Centre (1998).

Soil sample for laboratory analysis were collected from every horizon of every soil profiles. The purpose of soil laboratory analysis is supporting soil profile description for soil classification according to Soil Taxonomy from soil Survey Staff (1998). The soil were classified up to family level. The final results of soil classification and landform mapping are presented as soil map of Pesing Watershed

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(Appendix 1). Landform-soil relationships were explained descriptively based on their spatial distribution.

RESULTS AND DISCUSSION

Land Mapping Units of The Study Area

Land mapping units (LMU) in the study area were classified based on morphogenesis, morphostructure, morphology, and morphochronology and/or morphoarrangement. Those LMUs were identified through aerial photo interpretation using steps wise interpretation technique. Morphological unit was the first step followed by delineation of morphostructure passive (lithology), morphogenesis, and morphochronology and/or morphoarrangement units. However, the information order used for nomenclature purpose is morphogenesis, morphostructure, morphology, and morphochronology and/or morphoarrangement. The results of aerial photo interpretation were 10 types of landform units in the study area. They are listed in Table 1. For mapping purpose, these LMUs are symbolized using four codes:

F4P1 = Alluvial Plain of Pesing River
- F — Fluvial origin
- 4 — Alluvium of Pesing River
- P — Plain
- 1 — Alluvial plain

Table 1. Landform Units in the Study Area

Nr.	Code of LMUs	Genesis	Lithology	Morphology	Morphoarr/ Morphochron.
1	F5P1	Fluvial	Alluvium of Opak	Plain	Alluvial plain of Opak
2	F4P2	Fluvial	Alluvium of Pesing	Plain	Alluvium plain of Pesing
3	D3P3	Denudational	Colluvium	Plain	Inter-hills valley
4	D3P4	Denudational	Colluvium	Plain	Foot slope plain
5	S2M1	Structural	Breccias	Mountain	Escapment
6	D2M2	Denudational	Breccias	Mountain	Peak
7	D2H2	Denudational	Breccias	Hill	Isolated hill
8	S1H1	Structural	Tuffaceous Sandstone	Hill	Bakcslope
9	D1H3	Denudational	Tuffaceous Sandstone	Hill	Peak of hill
10	D1H4	Denudational	Tuffaceous Sandstone	Hill	Undifferentiated

Note : Morphoarr. : morphoarrangement
Morphochron. : morphochronology
The code for morphoarrangement is arranged for each morphological unit

Escarpment of structure breccias mountain (S2M1) has the steepest slope compared to other parts of the study area. Faulting and uplifting processes together with the information of the whole Gunungkidul Mountain have formed it. The specific signature of these formation processes express that this landform unit is controlled by its structure; therefore, this landform unit is classified as structural landform. Due to steep slope, mass movement processes are active and create most of the surface of this landform unit are dominated by out-crops. There are few areas that covered by soil parent material and/or soil as well as vegetation. That situation makes physical weathering predominant to other types of weathering process. Speroidal weathering as well as concoidal weathering, depend on rock types, are common features that can be found in most areas of this landform unit.

The landform unit of D2M2 is the highest area of the study area. It had been formed by uplifting process together with other parts of Baturagung Mountain. In the following time, mass wasting processes has been blurred the signature of uplifting process. Therefore, those landform units cannot be classified as structural landform anymore, but it is classified as denudational landform. Gully formation and development are still intensively working in the D2M2 landform unit. These processes are working more intensively under the present landuse type, i.e., dry land agriculture field. Under those landuse type, the land is only cultivated during the rainy season and in the beginning of dry season while in the end of dry season and in the beginning of rainy season the land is in bare condition. Therefore soil erosion as well as soil creep work more intensively in the beginning of rainy session.

D2H2 landform unit in the past time is part of D2M2. Due to the normal fault, which forms the S2M1 landform unit, the D2M2 had uplifted to the present position. The occurrence of normal fault is a clue for that assumption of D2H2 formation. Other assumption of the D2M2 formation is those landform unit formed by a big landslide of S2M1. Breccias layer in the D2H2 landform unit is not as thick as those of S2M2 become an evidence for this second assumption. The breccias layer is overlying on the tuffaceous sandstone layers that slightly decline to the direction of Pesing River. The porosity of the breccias is higher than those of the tuffaceous sandstone. Springs and seepages occur in the lower parts of the contact zone between these two rock layers.

The S1H1 landform unit is categorized as structural landform because its rocks stratification is still clearly identified through both aerial photo interpretation and field observation. The dip is parallel to the inclination of slope and this landform unit is located in the backside of the escapement located outside of the study area; therefore, it is named as back slope. Soil erosion and soil creep processes are active due to that situation. The product of weathering that laid on the underlying inclined impermeable rock is easily transported down slope by overland flow. This physical geography situation creates most areas of S1H1 are dominated by out-crops. Land management practice applied to control soil creep and soil erosion, such as terrace is not effective due to very thin soil and rock structure.

Other landform units with tuffaceous sandstone bedrock are classified as denudational landform. Those landform units are D1H3 and D1H4. The signature of structural control during their formation has not been recognized both through aerial photo interpretation and field observation. Most areas are only covered by thin-very thin soil and/or parent materials as weathering process of tuffaceous sandstone produce fine material that easily re-distributed by rainwater and overland flow.

According to the landform genesis, the landform units in the plain area can be classified into two groups, i.e., fluvial and denudational landform. There are two fluvial landform units in the study area, which are formed by Opak River (F5P1) and Pesing River (F4P2). The material sedimented by Opak River is pyroclastics of young Merapi Volcano, while those of Pesing River come from breccias and tuffaceous sandstone that predominant in the upper part of Pesing Watershed. Therefore, the fluvial landform of Opak River has coarser materials than those of Pesing River. The difference of alluviums founded in the study area is not only in particles size but also in mineralogical characteristics and in age of formation. The materials of young Merapi volcano are andesitics and it is recent materials. The breccias and the tuffaceous sandstone in the study area are mixed of volcanic materials both in particle size and in mineralogical characteristics formed during Teriary.

The denudational landform units are classified further based on their morphoarrangement into two groups, i.e., foot slopes of S2M1 and inter hills valley of D1H4. The differences in morphoarrangement express the differences in the materials constructed these landform units. Materials transported from tuffaceous sandstone hills dominate the D3P3 LMU, while the materials of D3P4 are originally come from breccias. The particles size of those materials come from tuffaceous sandstone is finer than those of materials come from breccias. The soils developed on these landform unit have different both in physical and chemical characteristics.

Soil Units in the Study Areas

Soil development processes vary according to the factors of soil formation. Pesing watershed has great variation in all five factors of soil formation; therefore soil units developed in this watershed are differs. Soil units in the study area identified in each landform unit are listed in Table 2. These soil units presented in Table 2 are the results of soil classification of pedons identified both through field and laboratory works. There were 22 soil profiles were made during the fieldwork, which represented more than 100 soil auger observations.

Most of soil units in the study area have *Ochric* epipedon due to one or more of the following four reason: too thin, too light in color, too coarse, too hard when in dry condition. Soil units located in the sloping areas tend to have *ochric* because soils have limited depth. Soil erosion and other types of mass movement may responsible to this situation. In the plain areas, however, the new materials are sandy and light color (andesitic materials). In the areas of D3P3 LMU, the soil unit has *Ochric* epipedon because the soil structure is too hard. Only the soil unit developed in D1H3 LMU has *Mollic* epipedon. The soil surface layer in this LMU is relatively thicker than those in the area surrounding because this LMU is less disturbed by human activities. Most of the hilly areas are used for agricultural purposes, however, in the top of the hill are preserved for forest. Due to better land cover, erosion process in the D1H3 LMU is less active than those area surrounding. Ultimately, the soil surface in D1H3 LMU is thick enough to be classified as *Mollic* epipedon.

Table 2. Soil Units in the Study Area

Nr	Code of LMUs	Diagnostic Properties			Soil Units
		Epipedon	Endopedon	Other	
1	F5P1	Ochric	-	-	Typic Udifluvents
2	F4P2	Ochric	Cambic	-	Vertic Eutrudepts
3	D3P3	Ochric	-	Slickenside	Chromic Hapludert
4	D3P4	Ochric	-	-	Typic Udorthents
5	S2M1	Ochric	Cambic	-	Lithic Eutrudepts
6	D2M2	Ochric	Cambic	-	Typic Eutrudepts
7	D2H2	Ochric	Argilic	-	Lithic Hapludalts
8	S1H1	Ochric	-	-	Lithic Udorthents
9	D1H3	Mollic	-	-	Lithic Hapludolls
10	D1H4	Ochric	Cambic	-	Lithic Eutrudepts

Endopedon development of soils units in the study area tends to have sub-surface horizon with finer soil texture. However, most of them are not yet meet with the requirement of *Argilic* and they are only meet with requirement of *Cambic* endopedon. Recognizable development of sub-surface diagnostic occurs in the area of D3P3 LMU. The soil units development in the area of D3P3 have clayey texture. Smectitic clays that have high potential for swelling and shrinking due to soil moisture changes dominate those soil units in D3P3. A specific signature due to swelling and shrinking is slickensides in the sub-surface horizon. Other soil units do not have sub-surface diagnostic soil properties because they are too thin and/or they have not enough time spans to develop.

System of Soil Unit Distribution in the Study Area

The systems of soil unit distribution that also known as soil systems are patterns of soil unit distribution in a certain landscape. The soil system are initiated from the river divide to the river channel. Therefore, in the study area, there are five systems of soil distribution. The soil systems of the study area are east, west, north and south of Pesing River, and the soil system in Alluvial Plain of Opak River.

The highest point in the eastern areas of Pesing River is the peak of breccia mountain (468m msl). From that peak to the escarpment the soil depth become shallower and become deeper to the valley bottom direction. Therefore, the soil units in the escarpment areas belong to *Lithic* sub-group. The distribution of *Lithic* sub-group soils are in association with out crop. In the foot slope areas, the soil units belong to other *Ordo*, i.e., Entisols. These soil units develop on coarse materials originated from transported materials of weathered breccias. In the valley bottom areas, the parent materials are mix of coarse materials originated from breccias and fine materials originated from tuffaceous sandstone. Those fine materials are ready materials to be altered to clay. In the high base environment, those clays tend to perform smectitic clays. Neverhteless, the soil units shrink significantly during dry season and produce cracks as an evidence for *Vertic* sub-group soils.

The soil systems in the west side of Pesing River are *Lithic Hapludolls* in the peaks of hill, *Lithic Udorthents* in the back slope areas, and Typic Undorthents in the foot slope areas. Both soil units which belong to *Lithic* sub-group are developing on the same parent materials. Due to differences in slope inclination and land use type, the soils in the pekas of hills contain higher organic materials than the soils in the back slope areas. The landuse type in the peaks of the hills is forest while in the back slope areas is rainfed agricultural field. Soil with higher content of organic materials have darker color than soils with lower content of organic materials. This color variation affects the soils in the peaks and the soils in the back slope areas are classified as *Mollisol* and *Entisols*, respectively. The soils in the foot slope areas develop on different parent material to the soils in the peaks of hills and the back slope areas. Continuous addition of new materials transported from the peaks of hills and the back slope areas have been disturbed the soil development in the foot slope areas. Therefore, the soil development in these areas is still in the initial stage.

The soil system in the north side of Pesing River are *Lithic Hapludolls*, *Lithic Eutrudepts*, and *Vertic Eutrudepts*, and *Vertic Eutrudepts*. The *Lithic Hapludolls* occupy the peaks of the hills areas and the *Vertic Eutrudepts* occupy the alluvial plain of Pesing River. The *Lithic Eutrudepts* are located in the hilly areas. The spatial distribution of *Lithic Eutrudepts* is in association with out crops of tuffaceous sandstone. Those *Lithic Eutrudepts* occupy the relatively gentle slope parts of the hilly areas. Most of the *Lithic Eutrudepts* are utilized for agricultural purposes. The *Lithic Hapludolls* and the *Lithic Eutrudepts* develop on the same parent materials. The *Lithic Happludolls* are characterized by the soil development in the surface soil while the Lithic Eutrudepts by the soil development in the sub-surface soil.

The soil system in the south side of Pesing River are slightly different to the ones in the north side. The soil sequence of *Lihic Eutrudepts*, *Chromic Hapludert*, and *Vertic Eutrudepts* occurs in the south side of Pesing River. The occurrence of *Chromic Hapluderts* occupy the inter hills valley creates the differences to the soil systems in the north side of Pesing River. The soil development in those inter hill valley is less disturbed be new sedimentation processes due to flood of Pesing River. Therefore, the soil development in the inter hills valley may form an ideal cracks and slickenside as an evidence for *Vertisols*. The soils development in the alluvial plain of Pesing River is not yet performs an ideal cracks and slickenside, therefore, they are grouped into *Vertic* sub group soils.

The soil developments in alluvial plain of Opak River vary due to position differences to the river channel. Those ones located closer to the river channel may perform *Aquic* characteristics and those one located more distance from the river channel may perform Oxyaquic characteristics. Those two areas of *Aquic* and *Oxiaquic* sub group soils are occasionally flooded by Opak River. The areas that are not anymore flooded by Opak River are occupied by *Typic Udifluvents* and this area is predominant among the other areas. For soil mapping purpose, the *Aquic* and *Oxiaquic* sub group soils are considered as inclusions.

CONCLUSIONS

The study area is considerable as small area with high variation in landform units. The morphology of the landform units varies from mountainous to plain. The lithology that constructs the landform units varies both in rock types and age of rock formation. Some different types of geomorphological processes have been active to create the present landform units in a specific spatial arrangement. Structural events combined with gravitational, erosional and depositional processes have been continuously modifying the landform units in the study area.

Some geomorphological processes, which active in the study area are soil erosion and sedimentation by water, many types of landslides, gravitational sedimentation, flood and inundation. These geomorphological processes have been disturbing the soil formation processes, therefore, most of the soil units in the study area are not yet developed enough and categorized as *Entisol* and *Inceptisols*. In the area that relatively stable, the soil formation processes tend to perform *Alfisols* and *Vertisols* for upland and lowland areas respectively. The distribution of *Mollisols* is only limited in the peaks of hills areas.

The formation factors of landform units have similarity to the formation factors of soil units. Soil parent materials are not always coming from the underneath rock that contained as lithological information in the landform units. The climate and organism in the soil formation factors are only influencing exsogenic geomorphological processes. Time in the factors of landform unit formation is started at the time of rock formation, while in the soil formation factors is started when the soil parent materials have been available. The relief is the only one that exactly the same factor both in soil and landform unit formation.

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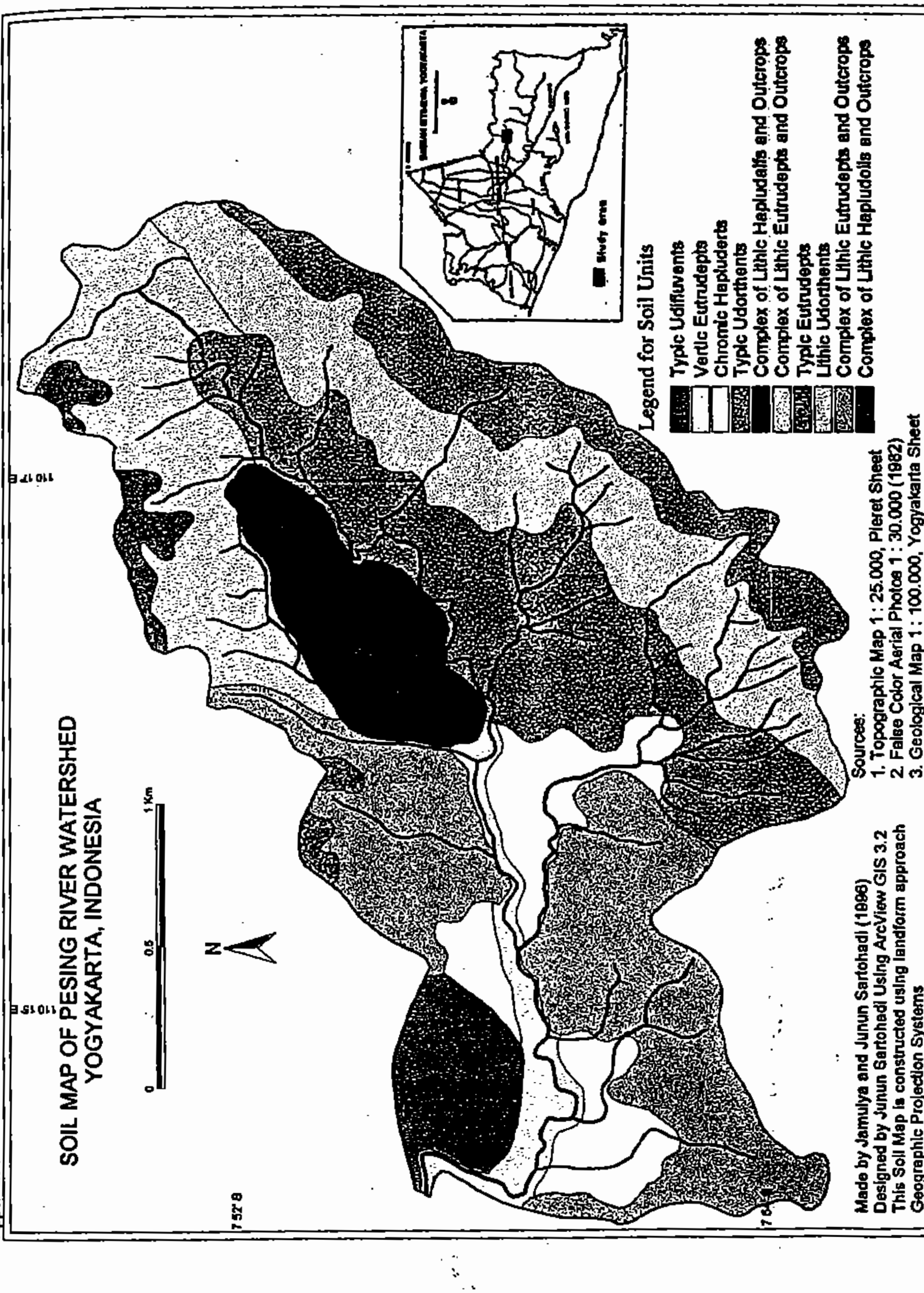
Appendix 1


SOIL MAP OF PESING RIVER WATERSHED
YOGYAKARTA, INDONESIA
0
0.5
1 Km
N
110 15' E
110 17' E
7 52' S
Legend for Soil Units
Typic Udifluvents
Vertic Eutrudepts
Chromic Hapluderts
Typic Udorthents
Complex of Lithic Hapludalfs and Outcrops
Complex of Lithic Eutrudepts and Outcrops
Typic Eutrudepts
Lithic Udorthents
Complex of Lithic Eutrudepts and Outcrops
Complex of Lithic Hapludolls and Outcrops
Study area
Made by Jamulya and Junun Sartohadi (1996)
Designed by Junun Sartohadi Using ArcView GIS 3.2
This Soil Map is constructed using landform approach
Geographic Projection Systems
Sources:
1. Topographic Map 1 : 25.000, Pleret Sheet
2. False Color Aerial Photos 1 : 30.000 (1982)
3. Geological Map 1 : 100.000, Yogyakarta Sheet

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Appendix 2 Field Soil Data

LMU	Horizon	Depth (cm)	Color	Texture	Structure	Consistency	Hor.Trans.
F5P1	A	0 -20	10YR4/4	CL	f. granular	s. plastic	smooth
	AB	20 - 39	10YR3/2	SCL	granular	s. plastic	smooth
	Bw1	39 - 72	10YR4/4	SCL	ang. blocky	s. plastic	smooth
	Bw2	72 - 112	10YR4/4	SCL	ang. blocky	s. plastic	smooth
	BC	112 - 128	10YR4/2	L	massive	n. plastic	smooth
	C	128 +	10YR4/1	LS	s. grain	n. plastic	-
F4P2	Ap	0-20/30	10YR2/2	SiC	granular	plastic	wavy
	Bw1	20/30-50/60	10YR4/1	C	blocky	plastic	wavy
	Bw2	50/60-100	10YR4/4	CL	massive	plastic	wavy
	BC	100+	10YR4/4	L	massive	n. plastic	-
D3P3	Ap	0-20	7.5YR3/2	CL	granular	plastic	smooth
	Bw	20-50/56	7.5YR3/4	SiC	ang. blocky	plastic	wavy
	Bss1	50/56-88/99	7.5YR3/4	C	ang. blocky	plastic	wavy
	Bss2	94-115	7.5YR3/4	C	ang. blocky	plastic	wavy
	BC	115+	7.5YR3/4	CL	massive	plastic	-
D3P4	Ap	0-13	10YR4/4	SiC	s. blocky	s. plastic	smooth
	C1	13-31	10YR4/3	CL	massive	s. plastic	smooth
	C2	31-60	10YR4/4	CL	massive	s. plastic	smooth
	Cr	60+	10YR4/4	L	massive	n. plastic	-
S2M1	A	0-14	10YR3/1	L	granular	n. plastic	smooth
	Bw	14-41	10YR4/1	CL	ang. blocky	s. plastic	smooth
	R	41+	-	-			
D2M2	Ap	0-11	10YR3/3	SiC	c. granular	s. plastic	smooth
	AB	11-24	10YR3/3	SiC	s. blocky	s. plastic	smooth
	Bw1	24-41	10YR3/3-4/3	SiC	s. blocky	plastic	smooth
	Bw2	41-62	10YR4/3	SiC	s. blocky	plastic	smooth
	Bw3	62-87	10YR4/4-3/4	SiC	s. blocky	plastic	smooth
	BC	87-160	7.5YR4/4	L	s. blocky	s. plastic	smooth
	Cr	160+	7.5YR4/3	L	massive	s. plastic	smooth
D2H2	A	0-19	7.5YR4/4	L	granular	s. plastic	smooth
	Bw	19-44	7.5YR3/4	CL	f. prismatic	s. plastic	irregular
	R	44+					
S1H1	Ap	0-20/25	10YR4/1	CL	c. granular	plastic	wavy
	C	20/25-45	10YR8/1	CL	massive	plastic	irregular
D1H3	Ap	0-18	10YR3/1	CL	c. granular	s. plastic	smooth
	Bw	18-48	10YR3/1	CL	ang. blocky	s. plastic	wavy
	BC	48-62	10YR4/1	CL	ang. blocky	s. plastic	irregular
	R	62+					
D1H4	Ap	0-18	10YR3/3	SiC	f. granular	s. plastic	smooth
	Bw1	18-34	10YR3/3	SiC	s. blocky	s. plastic	smooth
	BC	34-45	10YR3/3	SiC	s. blocky	plastic	irregular
	R	45+					

Appendix 3a. Laboratory Soil Data

LMU	Horizon	Depth	Texture			pH		C	N	P_2O_5
			Sand	Silt	Clay	H_2O	KCl			
		(cm)	%					%		ppm
F5P1	A	0 -20	26.31	48.23	25.46	6.80	7.03	0.41	0.058	9.35
	AB	20 - 39	19.85	55.25	24.90	6.80	7.01	0.40	0.057	8.34
	Bw1	39 - 72	19.55	60.34	20.11	6.75	7.00	0.41	0.058	8.35
	Bw2	72 - 112	18.82	59.38	21.80	6.77	7.00	0.40	0.057	7.32
	BC	112 - 128	40.28	49.25	10.47	6.65	7.00	0.33	0.048	6.31
	C	128 +	61.87	29.20	8.93	6.65	7.00	0.21	0.031	2.29
F4P2	Ap	0-20/30	12.27	45.48	42.25	6.90	6.92	0.88	0.081	12.98
	Bw1	20/30-50/60	25.47	32.45	42.08	6.54	6.71	0.98	0.080	13.65
	Bw2	50/60-100	27.82	34.86	37.32	6.45	6.50	0.55	0.059	12.59
	BC	100+	38.85	36.25	24.90	6.44	6.50	0.69	0.066	8.25
D3P3	Ap	0-20	21.01	40.98	38.01	6.87	6.73	1.12	0.100	11.20
	Bw	20-50/56	19.06	41.29	39.65	6.77	6.75	1.10	0.090	12.22
	Bss1	50/56-88/99	22.56	35.24	42.20	6.65	6.60	1.19	0.110	10.82
	Bss2	94-115	21.78	33.27	44.95	6.55	6.50	1.12	0.100	11.20
	BC	115+	25.24	35.52	39.24	6.42	6.50	0.90	0.070	12.86
D3P4	Ap	0-13	47.72	25.50	26.78	5.90	4.30	0.56	0.050	8.08
	C1	13-31	42.35	28.25	29.45	5.60	4.00	0.35	0.030	4.95
	C2	31-60	48.20	29.35	23.45	5.80	4.10	0.09	0.010	6.77
	Cr	60+	68.31	21.30	10.39	5.80	4.00	0.04	0.010	1.97
S2M1	A	0-14	32.54	41.58	25.88	7.01	6.50	1.21	0.120	10.18
	Bw	14-41	30.56	40.57	28.87	7.00	6.50	0.87	0.094	5.19
	R	41+								
D2M2	Ap	0-11	25.50	30.20	44.30	5.30	4.70	1.43	0.140	20.01
	AB	11-24	32.45	32.47	35.08	5.40	4.70	1.20	0.120	18.31
	Bw1	24-41	34.52	28.76	36.76	5.50	4.60	0.85	0.090	18.18
	Bw2	41-62	40.60	24.90	34.50	5.40	4.60	0.53	0.070	16.08
	Bw3	62-87	49.70	22.90	27.40	5.90	4.60	0.35	0.040	11.12
	BC	87-160	46.62	28.30	24.08	6.00	4.60	0.33	0.040	11.41
	Cr	160+								
D2H2	A	0-19	42.00	35.26	22.74	6.62	6.53	0.89	0.090	9.44
	Bw	19-44	36.28	31.19	32.53	6.56	6.50	0.93	0.090	10.56
	R	44+								
S1H1	Ap	0-20/25	42.15	26.54	31.31	7.10	6.50	0.87	0.075	8.20
	C	20/25-45	45.41	24.56	30.03	7.00	6.80	0.73	0.070	6.90
D1H3	Ap	0-18	39.05	28.01	32.94	6.70	6.60	1.15	0.100	10.15
	Bw	18-48	38.71	27.07	34.22	6.90	6.50	0.97	0.090	8.75
	BC	48-62	41.27	27.98	30.75	7.00	6.60	0.95	0.080	5.46
	R	62+								
D1H4	Ap	0-18	15.25	40.21	42.54	5.30	4.70	0.78	0.070	9.24
	Bw1	18-34	15.34	39.28	45.38	5.40	4.70	0.71	0.066	7.12
	BC	34-45	11.46	43.25	45.29	5.50	4.60	0.66	0.061	5.28
	R	45+								

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Appendix 3b. Laboratory Soil Data

LMU	Horizon	Depth	CEC (NH4-Oac 1N.pH 7)				CEC	Base Sat.
			Ca	Mg	K	Na		
		(cm)	me/100g soil					%
F5P1	A	0 -20	23.72	28.12	1.25	0.80	58.24	92.54
	AB	20 - 39	26.65	18.01	1.22	0.97	61.00	93.20
	Bw1	39 - 72	23.22	17.05	1.15	0.84	57.34	91.14
	Bw2	72 - 112	24.85	26.98	1.17	0.86	59.03	91.24
	BC	112 - 128	16.16	17.28	1.09	0.70	39.06	90.20
	C	128 +	10.35	11.45	1.08	0.78	26.73	88.52
F4P2	Ap	0-20/30	37.01	38.97	0.67	0.95	79.77	97.77
	Bw1	20/30-50/60	32.27	35.24	0.68	0.80	72.38	95.32
	Bw2	50/60-100	28.28	32.15	0.62	0.90	67.32	92.02
	BC	100+	19.49	23.87	0.58	0.64	51.72	86.19
D3P3	Ap	0-20	43.91	25.05	33.25	1.12	61.25	99.01
	Bw	20-50/56	41.62	25.13	30.99	1.16	59.98	97.25
	Bss1	50/56-88/99	42.26	26.24	31.26	1.17	60.98	98.09
	Bss2	94-115	39.21	23.88	31.56	1.01	60.23	95.66
	BC	115+	37.21	23.57	26.02	0.82	56.42	91.28
D3P4	Ap	0-13	12.03	8.15	0.25	0.14	21.21	96.98
	C1	13-31	22.73	11.89	0.14	0.20	26.30	100.00
	C2	31-60	27.37	12.92	0.21	0.26	21.10	100.00
	Cr	60+	19.08	9.25	0.09	0.18	20.16	100.00
S2M1	A	0-14	21.15	17.84	0.69	0.88	41.44	97.87
	Bw	14-41	22.18	16.54	0.56	0.76	41.92	95.52
	R	41+						
D2M2	Ap	0-11	17.45	7.83	0.68	0.15	33.97	76.86
	AB	11-24	16.83	7.31	0.41	0.18	33.88	72.99
	Bw1	24-41	16.31	7.51	0.33	0.23	31.25	78.02
	Bw2	41-62	16.05	6.36	0.24	0.24	30.12	76.00
	Bw3	62-87	14.23	7.54	0.17	0.33	29.30	76.01
	BC	87-160	14.48	6.85	0.22	0.28	29.90	73.01
	Cr	160+						
D2H2	A	0-19	17.75	22.85	0.78	0.60	47.11	89.12
	Bw	19-44	11.02	20.16	0.71	0.67	42.15	77.25
	R	44+						
S1H1	Ap	0-20/25	15.46	14.57	0.78	0.47	39.73	78.73
	C	20/25-45	11.87	9.98	0.58	0.44	33.98	67.30
D1H3	Ap	0-18	20.21	15.42	0.72	0.91	42.00	88.71
	Bw	18-48	19.86	14.23	0.65	0.86	41.13	86.56
	BC	48-62	17.25	12.34	0.58	0.73	38.85	79.54
	R	62+						
D1H4	Ap	0-18	18.35	12.24	0.55	0.87	38.73	82.65
	Bw1	18-34	16.34	10.98	0.53	0.84	36.95	77.65
	BC	34-45	10.98	8.25	0.57	0.78	31.13	66.11
	R	45+						