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Paddy Land Suitability Classification in relation to Its Potential for Multiple Cropping Systems

――A Case Study of the Central Plain of Luzon――

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Introduction

Where agricultural land cannot be expanded to keep pace with population growth, a heavy burden is imposed upon present cultivated land for greater production. The adoption of multiple-cropping systems has been suggested as a means for better and fuller utilization of limited land and other related agricultural resources.

Over the past few years The International Rice Research Institute (IRRI) has developed a methodology for identifying more productive and intensive rice-based cropping patterns for the small rice farmer in South and Southeast Asia. The introduction of the improved cropping patterns is, however, complex, because they are highly environment-specific; the performance of crops either individually or in combination tends to vary from location to location. It is therefore important that a cropping pattern's domain of adaptation be explicitly specified before it is recommended for implementation.

The most basic set of factors relating to the performance of crops and cropping patterns comprises those associated with the physical environment. Physical environment needs to be identified and classified in such a way that the divisions of the classification system will reveal predictive information about the biological performance of introduced cropping patterns.

Within a rainfall pattern, landform and soil properties play major roles in modifying field-water regimes, i.e., the presence and availability of moisture in the soil profile, the availability of oxygen in the root zone, the probability of flooding, etc. The dependence of water regimes on landforms is mainly dictated by the water table and the degree of water enrichment. The seasonally fluctuating ground water table is almost independent of soil-related factors. The perched water table, however, which also influences the soil hydrology, is in part dependent on pedological factors, namely, soil texture, clay mineralogy and the presence of pans.

It is obvious that these soil properties alone do not provide sufficient criteria for land-suitability classification with respect to potential for rice-based multiple-cropping systems. However, there are presently no other established methodologies for classifying lands that allow their evaluation for potential crop-

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ping systems. We have attempted, therefore, to identify the soil-suitability groupings in the Central Plain of Luzon based on the soil properties.

We also discuss the adaptability to the soil-suitability groups of the recommended rice-based cropping patterns that have been derived from performance tests of these patterns conducted by the IRRI–BPI (Bureau of Plant Industry) project team in Pangasinan.

Another method of land classification that might serve our purpose is the use of LANDSAT imageries, on which the colors, tones and textures that appear are closely correlated to field water regimes and landuse. Although this scheme is not yet well established, we have attempted to develop a classification scheme based on interpretation of LANDSAT imagery with which to evaluate the potential of paddy lands for multiple-cropping systems. We will call it land-management groupings.

The similarities and differences between the two classification schemes are discussed and their merits and demerits evaluated. The schemes are also compared with existing land surveys and other available land evaluation reports conducted by other agencies.

Materials and Methods

1. *Study Area*

The study area covered paddy land in the whole Central Plain of Luzon, an expanse of approximately 600,000 ha of low flat terrain. Soil-suitability groupings were established for the whole plain, while land-management groupings were made in selected areas: the Pangasinan sub-basin (areas A and B), and the Tarlac-Pampanga area (area C) in Fig. 1.

2. *Materials*

Materials used in the classifications are:

(1) 1 : 50,000 topo maps

(2) 1 : 250,000 landuse maps

(3) LANDSAT imageries (1 : 250, 000 false-color imageries taken in May, July, August, November, December and February)

(4) Land descriptions and field observations of cropping systems from a reconnaissance survey made in August to September, 1979 by Fukui, H. and Kaida, Y.; and in February, 1980 by Kaida, Y., both from the Center for Southeast Asian Studies (CSEAS), Kyoto University.

(5) Results of cropping-pattern tests and component-technology studies conducted by the IRRI–BPI Cropping Systems Research Project in Manaoag, Pangasinan from 1975 to 1979.

(6) Soil maps, physical descriptions and analytical data of soils in Pangasinan, Tarlac, Nueva Ecija, Bulacan and Pampanga Provinces. Scale of the soil maps is 1 : 100,000 to 1 : 150,000 depending on provinces. These were collected from the Philippine National Irrigation Administration (NIA), the Bureau of Soils (BS) and the Bureau of Plant Industry (BPI).

3. *Soil-Suitability Groupings (SSG)*

Soil properties were used to construct soil-suitability groups for rainfed rice-based cropping patterns. These properties are: dominant soil texture in the profile, drainage class, and organic matter content.

Soil Texture Because soil texture strongly influences internal drainage, soil

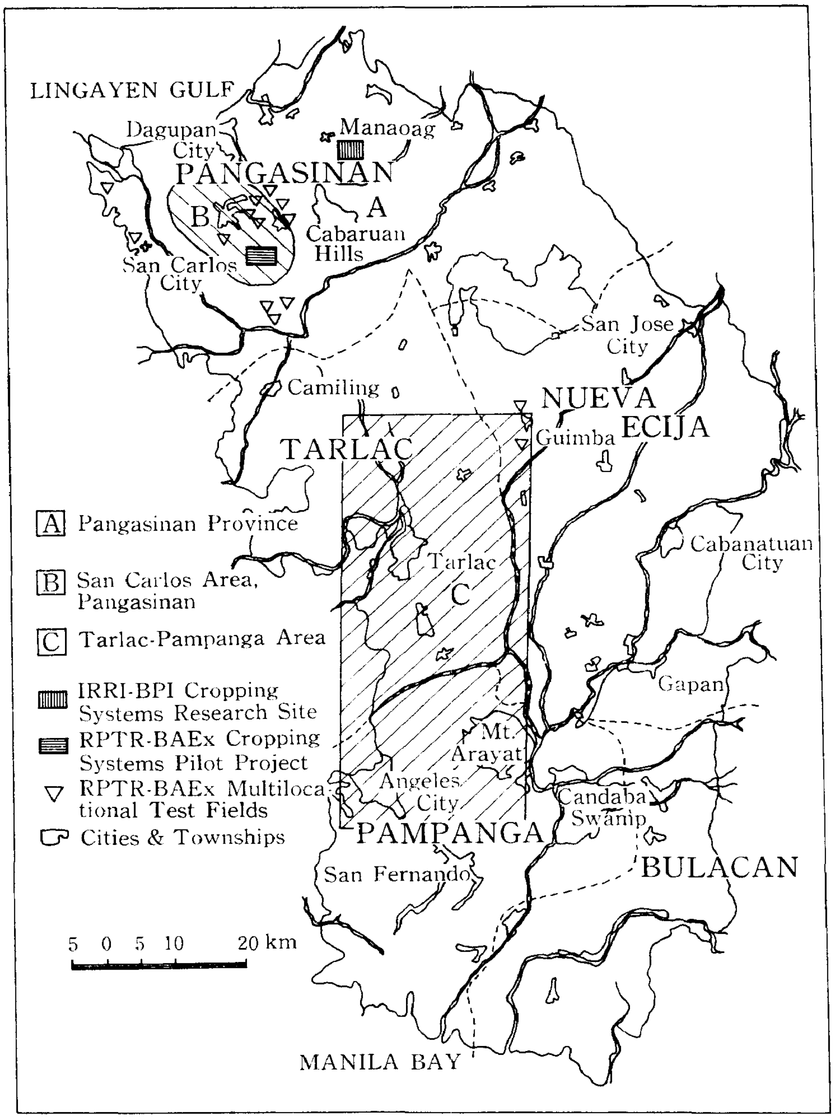


Fig. 1 Locations of the IRRI–BPI CS Research Site, RPTR–BAEx CS Pilot Project, Multilocational Test Fields and Areas Where Most Similarities and/or Differences Were Observed between Soil-Suitability and Land-Management Groups

moisture-retention capacity, gaseous exchange and rooting pattern, the dominant texture was used as one criterion for grouping soils.

The textural classes are:

(1) Light: Soils with a dominant texture of sand (S), fine sand (FS), or loamy fine sand (LFS).

(2) Medium-light: Soils with a dominant texture of sandy loam (SL), sandy clay loam (SCL), or loam (L).

(3) Medium-heavy: Soils with a dominant texture of silty loam (SiL), silty clay loam (SiCL), or clay loam (CL).

(4) Heavy: Soils with a dominant texture of silty clay (SiC) or clay (C).

The suitability of the soil-texture classes for rice culture increases from the coarse to the fine-textured (Table 1). Texture is, moreover, perhaps the single soil property that controls the potential soil-management alternatives in cropping systems. Aside from directly determining the suitability of particular upland crops to follow rice, e.g., root crops versus legume crops, soil texture dictates how the soil can be managed for the establishment of these upland crops after rice. For example, zero tillage, a method of establishing an upland crop after rice by making furrows without the usual full tillage operations, resulted in better production in medium-textured than in fine-textured soils. A medium-textured soil allows easier root penetration into the lower layers, while immediate drying of the surface creates a dry soil mulch that reduces evaporation losses. In fine-textured soils, on the other hand, drying is immediately accompanied by cracking, which hastens

Table 1 Soil Texture and General Suitability for Rice

Soil Texture	Textural Class	Landuse	Suitability for Rice
Sand Fine Sand Loamy Fine Sand	Light	Normally Non-paddy	Less Suitable
Sandy Loam Loam Silty Loam	Medium-light	Normally Non-paddy / Common Textural Classes for Paddy	↕
Silty Clay Loam Clay Loam	Medium-heavy	Common Textural Classes for Paddy	↕
Silty Clay Clay	Heavy	Common Textural Classes for Paddy	More Suitable

the drying of the deeper layers of the soil. Consequently, the roots proliferate along the cracks, which are subject to rapid drying.

Drainage The drainage condition of a particular soil is affected by soil texture, horizonation and other land factors. Drainage strongly influences gaseous exchange and rooting patterns. The drainage classes are:

(1) Good to excessive: Soils with no impedement to internal drainage throughout the soil profile. The surface color is generally brownish (brown to very dark gray brown).

(2) Moderately good: Soils with some internal drainage restriction due to the presence of a less permeable layer or a relatively high water table, addition of water through interflow, or combinations of these conditions. Surface color ranges from very dark brown to very dark gray brown.

(3) Poor: Soils forming clay pans, with a high water table at or near the surface during the rainy season, and addition of water due to interflow, or combinations of these conditions. Surface color ranges from very dark brown to very dark gray, and the B-horizon from dark brown to grayish brown.

(4) Very poor: Soils with a water table at or near the surface for an extended period and pedologically formed layers which tend drastically to reduce percolation. The layer may be a hard pan, a clay pan, or a layer of high clay content relatively close to the surface. The dominant surface color is dark gray.

Organic Matter Nitrogen response, cation-exchange capacity and moisture-retention capacity are influenced by soil organic matter. Accumulation of soil organic matter is influenced by pedogenetic factors, of which water regime is important. Soils were placed into three classes with respect to organic matter content:

(1) Low: less than 1%

(2) Medium: 1 to 2%

(3) High: over 2%

Based on these soil properties, 23 major soil types in the Central Plain of Luzon were grouped into five soil-suitability classes:

(1) Suitability Group I: Light soils that are excessively well drained (non-paddy soils).

(2) Suitability Group II: Medium-light, well-drained soils.

(3) Suitability Group III: Medium-light, moderately well-drained soils.

(4) Suitability Group IV: Medium-heavy, poorly drained soils.

(5) Suitability Group V: Heavy-textured, very poorly drained soils. They are shown in Table 2.

Table 2 Description and Analytical Data of Soils in the Central Plain of Luzon

Soil Type	Code Number	Texture		Color		Mottles	Drainage	pH	OM (%)
		Surface	Dominant	Surface	B-horizon				
Angeles FSL	73	FSL	SiL	Gray Brown	Gray	Few	Good to Exc.	7.9	0.2
La Paz FS	77	L	FS	Gray Brown	Gray	Few	Good	6.2	0.1
Luisita FS	83	S	SL	Dk. Brown	—	None	Excessive	—	0.2
Luisita SL	84	L	SCL	Dk. Gr. Brown	Dk. Gr. Brown	Few	Moderate	5.5	1.2
La Paz FSL	81	SL	S	Dk. Gr.	—	Few	Good	6.0	1.0
Luisita FSL	85	SL	SiL	V. Dk. Gray	Light Gray	None	Good	6.9	1.8
Sn. Manuel FSL	95	FSL	LFS	Brown	—	None	Good	6.0	1.8
Tarlac SCL	89	SL	SCL	V. Dk. Gr. Br.	Dk. Gr. Brown	Few	Moderate	6.5	1.2
Bantog SiL	390	CL	CL	Br. to Dk. Br.	Dk. Br. to Light Br.	Few	Poor	6.0	1.5
Maligaya SiL	116	CL	SiCL	Dk. Br. to Br.	Light Br. to Gr. Br.	Few	Poor	7.0	1.8
Umingan SiL	99	SiL	SiL	Dk. Gray	Brown	Abundant	V. Poor	6.5	2.0
Sn. Manuel SiL	82	SiL	L	V. Dk. Gr. Br.	Gr. Brown	Few	V. Poor	7.0	1.2
Quingua SiL	5	SiL	SiL	Dk. Gr.	Light Brown to Light Yellowish Br.	Few	Good	5.8	2.5
Sn. Manuel SiCL	94	SiCL	SiCL	Br. to Dk. Br.	Br. to Dk. Br.	Abundant	V. Poor	6.0	1.6
Quingua SiCL	285	SiCL	SiCL	Dk. to Pale Br.	Dk. to Pale Br.	Few	Moderate	6.3	1.7
Annam CL	98	CL	SiC	Brown	Gray	Abundant	Poor	6.5	1.8
Bantog CL	16	C	C	V. Dk. Gr.	Grayish Br.	Abundant	Poor	6.2	2.0
Maligaya CL	117	CL	C	Dk. Br. to Br.	Dk. Br. to Lt. Br.	Few	Poor	5.6	1.8
Sn. Fabian CL	102	SiCL	CL	Gray	Brown	Few	Poor	5.0	2.0
Sn. Manuel CL	236	CL	C	V. Dk. Gr.	Dk. to Pale Br.	Few	Moderate	7.3	1.2
Tarlac CL	86	CL	CL	Dk. Gr.	Grayish Br.	Few	Poor	6.3	1.5
Sn. Fernando C	68	C	C	Dk. Gr.	Dk. Br.	Abundant	V. Poor	6.8	1.5
Zaragoza C	90	C	C	Dk. Gr.	Grayish Br.	Abundant	V. Poor	5.4	2.4

Sources: FAO–PBS [1972a] and NIA soil survey reports (mimeo descriptions plus working maps)

Organic matter content was used to adjust the classification of some soils which did not seem to fit their original suitability group on the basis of texture and drainage.

4. Land-Management Groupings (LMG)

Colors, tones and textures that appear in LANDSAT false-color imagery scenes are closely correlated with field-water regimes and landuse. Depending mainly on the field survey of Pangasinan by Fukui and Kaida [1981], we tried to interpret LANDSAT imagery scenes covering the Pangasinan, Tarlac-Pampanga, and Tarlac-Nueva Ecija areas. We hypothesized that, in order to see most clearly the differences in cropping areas related to field-water regimes, LANDSAT imageries taken in the early dry season (December or January) should be compared with those of the early wet season (June, July or August).

To standardize the description of LANDSAT imageries, the terminology proposed by Fukui and Kaida [*ibid.*] was used:

(1) Matrix/mosaic: Matrix was used when one element was dominant, otherwise mosaic was used.

(2) Vegetation: Very thick, thick, moderately thick, and thin.

(3) Field-water regimes: With surface water (shallow, deep), wet, and dry.

(4) Shape of elements:

(a) Spots — round or oval with clear boundary.

(b) Large spots — 2 to 3 mm in length or diameter on 1: 250,000 scale.

(c) Cloudy spots — round or oval with unclear boundary.

(d) Dots — too small for the shape to be identified.

(e) Ribbons — meandering, elongated, or continuous with clear boundary, e.g., levees along a meandering river.

(5) Abundance: Very many, many, some, few, very few.

Four land-management groups (LMG) were established based mainly on field-water regimes as interpreted from LANDSAT false-color imagery scenes. Water regimes characteristic of each of the groups will be described later.

Results and Discussion

1. Soil-Suitability Groupings and Suggested Cropping Systems

Selected physical and chemical properties used to construct soil-suitability groups are presented in Table 2. Not all combinations of soil texture and drainage classes are represented in the suitability groupings. For instance, a heavy-textured soil with good drainage does not exist. Similarly, light-textured soils with poor drainage are seldom found.

An example of soil-suitability groupings for Pangasinan Province based on soil types is shown in Fig. 2. (The original scale of the soil map is 1: 150,000.) The same classification scheme was used to generate a map of soil-suitability groupings covering the whole Central Plain of Luzon (Fig. 3). Furthermore, the soil-suitability groupings were reproduced in Fig. 4–a for Pangasinan Province, and in Fig. 5–a for Tarlac-Pampanga area (area C in Fig. 1) to facilitate comparison

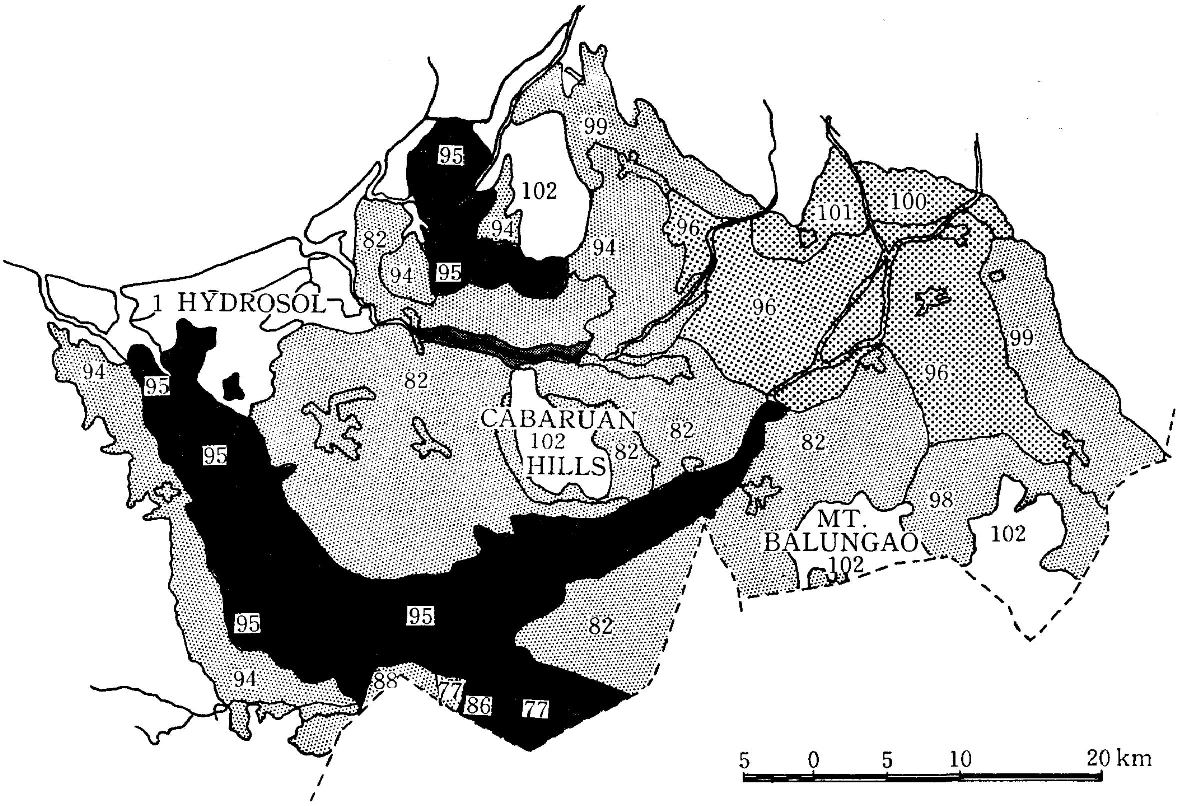


Fig. 2 Soil-Suitability Groups of Pangasinan Province Based on Soil Survey Reports

- I ☐ Non-paddy soils: Hydrosol (1), mountain or rolling terrain mapped as Annam clay (102)
- II ■ Medium-light, well-drained soils. Require long period of rainfall to become fully recharged before they remain flooded at the peak of the rainy season. These soils are utilized for paddy rice if located in lower landscape positions, otherwise utilized mainly for upland crops: La Paz FS (77), San Manuel FSL (95)
- III ▩ Medium-light, moderately well-drained soils. Do not take as long to become flood and in many cases flood earlier than soils in Group II if heavy rain causes water table to rise rapidly or if soils are found in lower landscape positions: Umingan SL (100), FS (101), San Manuel SL (96)
- IV ▨ Medium-heavy, poorly drained soils. Remain excessively wet for upland crops: San Manuel SiL (82), SiCL (94), Annam CL (98), Umingan SiL (99)

with results from other classification schemes.

By assuming a rainfall distribution similar to that in Manaoag in Pangasinan, namely, 3–4 wet months of not less than 200 mm rainfall per month and 5–6 dry months of not more than 100 mm, rice-based cropping patterns for each suitability group can be designed. Recommended cropping patterns are based on the results of pattern performance tests conducted by the IRRI–BPI cropping systems research project at Manaoag, Pangasinan from 1975 to 1979. In addition, multilocational trials with farmer-cooperators using the same procedures for testing cropping patterns were started in 1977 by the IRRI Rice Production Training and Research Department (RPTR) in cooperation with the Philippine Bureau of Agricultural Extension (BAEx). The pilot project in Pangasinan and fourteen farmer-cooperators in

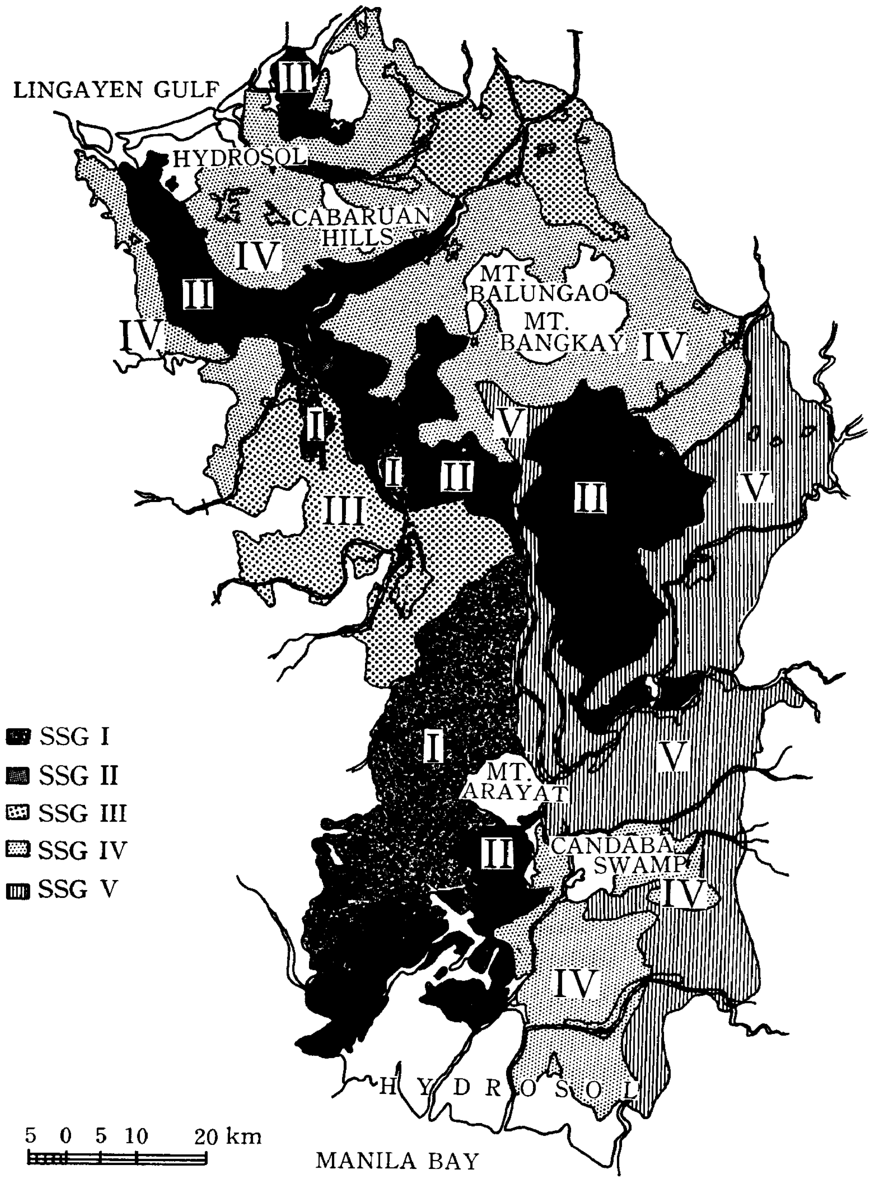


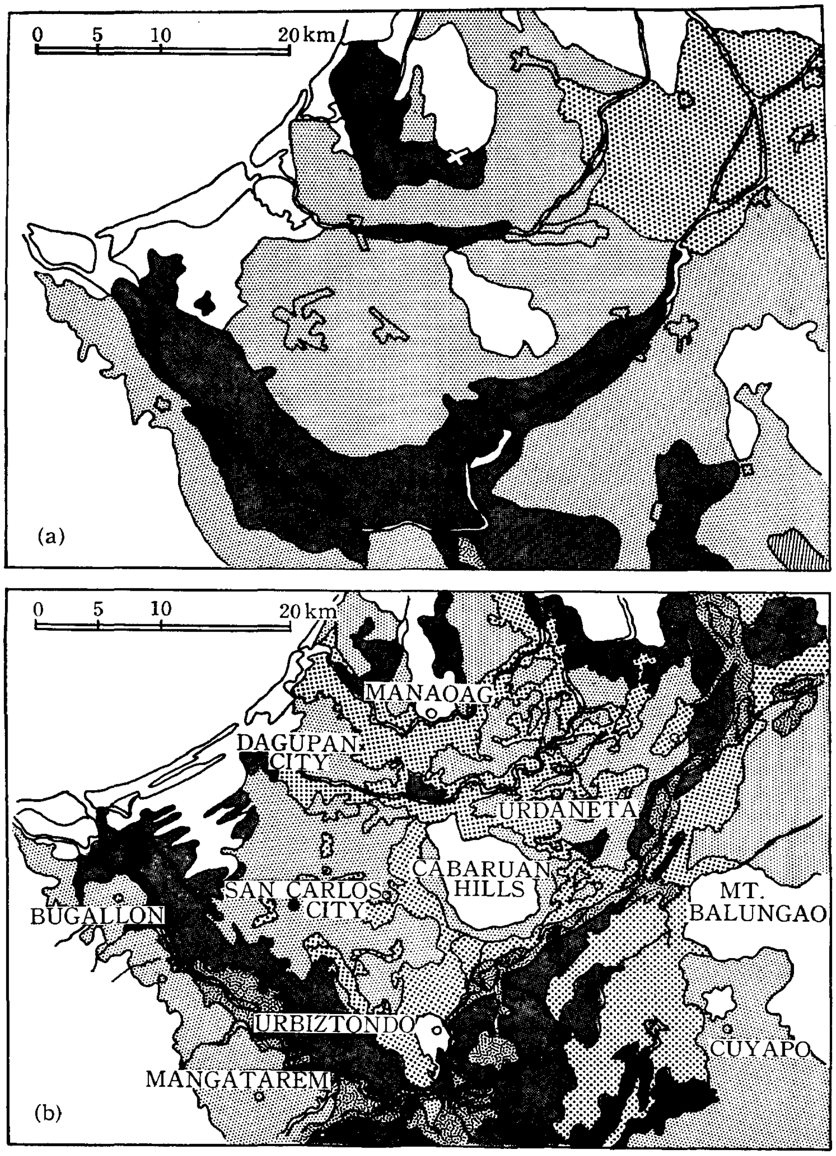
Fig. 3 Soil-Suitability Groups in the Central Plain of Luzon

other locations are shown in Fig. 1. The cropping patterns advocated for further tests after crop year 1977–78 and the experiences of the multilocational units were used as bases for the suggested cropping patterns for the identified soil-suitability groups.

Suitability Group I These are not suited for rice-based cropping systems but are well adapted to upland crops including sugarcane. A soil survey of Pangasinan indicated that only a very minor portion of soils fell into this group, in areas too small to be shown on the soil-suitability map (Fig. 2). These are therefore included with Group II. Most of the Group I soil was found in the Tarlac-Pampanga area (Fig. 3 and Fig. 5–a).

Suitability Group II
Soils classified in Suitability Group II were mostly found in flood plains along the big rivers or in low landscape positions where deposition of light soil materials is extensive.

Three alternative cropping patterns are suggested for this group (Table 3): (1) Dry seeded rice (DSR, IR36) may be planted from mid-May to early June, relying on occasional rains for early growth. Towards the end of the wet season, peanuts can be planted after deep plowing to assure rapid infiltration of late rains and good aeration; (2) Green corn (GC) may be planted after initial rains in mid-May provided sufficient rain has fallen to wet the profile to 30–40 cm. Tillage for corn should leave the field with a fairly rough surface. After corn is harvested, a transplanted rice crop (TPR) can be planted using 35–40-day-old IR36 seedlings. Puddling for this crop need not be intense. The crop should be in the field for 75–80 days. A



SSG I/LMG I
SSG II/LMG II
SSG III/LMG III
SSG IV & V/LMG IV
NON-ARABLE LAND

Fig. 4 Soil-Suitability Groups (SSG), and Land-Management Groups (LMG) of Pangasinan Province

mungbean or peanut crop should be planted after the TPR crop is harvested; (3) A third possibility, but one of which there is no first-hand experience on soils in this group, consists of a GC crop planted in wide (1.25 to 1.75 m) rows, with dry seeded rice (DSR, IR 36) planted between corn rows about 40 days later. Either mungbeans or peanuts can be planted after the rice is harvested.

Suitability Group III

Soil survey reports indicate that soils in this group are mostly levee soils developed on the banks of major rivers like the Agno river in Pangasinan and the Odonnel and Tarlac rivers.

This group might considerably reduce the potential for dry season paddy rice production, but should not limit upland crop potential. Although the cropping patterns for Group II are also suggested for this group (Table 3), the green corn (GC) may often be damaged by late heavy rains. Because of their long field-duration, mungbeans should be substituted for peanuts. The rice crop should be less subject to soil moisture stress than that in Group II soils.

Suitability Group IV

Soils of this group are the most extensive in northeastern Central Luzon, especially in Central Pangasinan and the northern portion of Nueva Ecija, south of Mt. Bangkay. The area west of Candaba swamp extending south to where the Angat river drains was also classified in this group.

This group should not limit paddy rice production but would considerably reduce

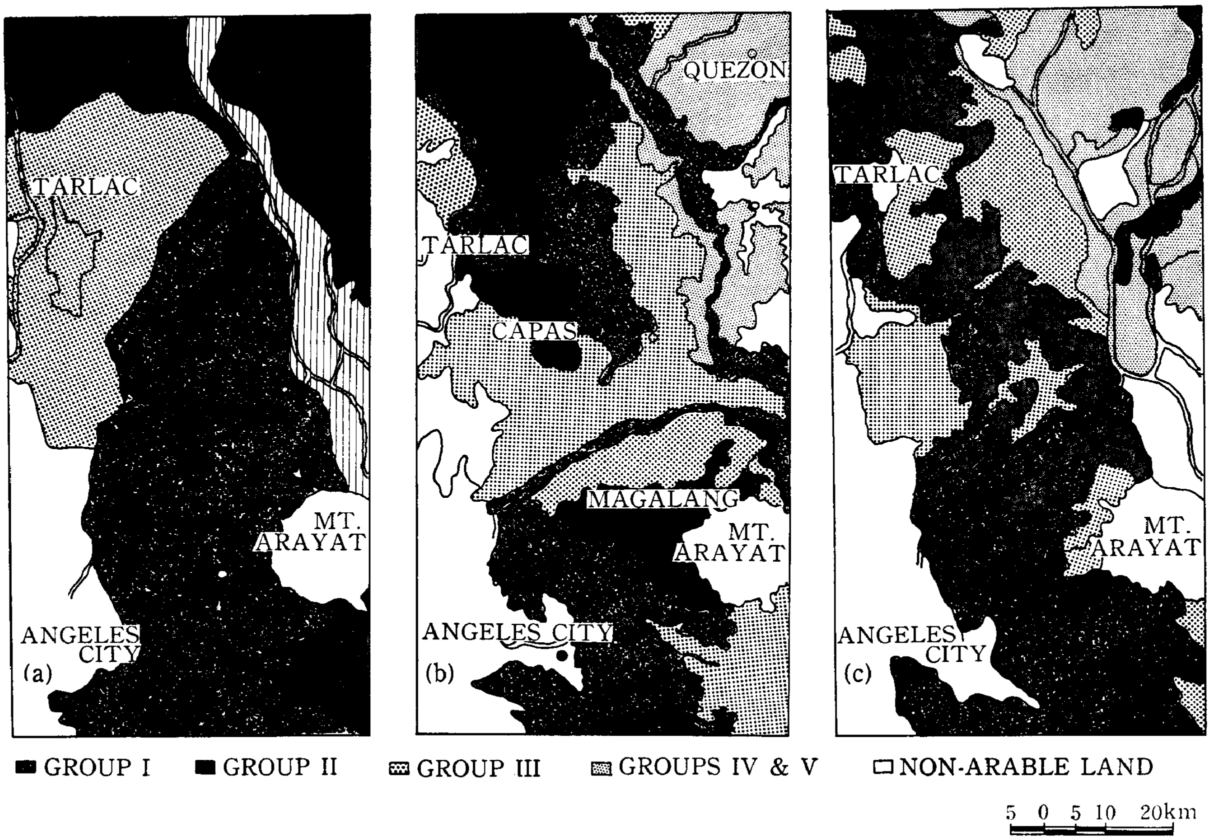


Fig. 5 Comparison of the Three Classification Schemes: SSG (a), LMG (b), and NIA Classification (c)

Table 3 Suggested Cropping Patterns for Soil-Suitability Groups under Rainfed Conditions in the Central Plain of Luzon

Suitability Group[1)]	Soils	Suggested Patterns[2)]
I	San Manuel S (97), Luisita FS (83), Angeles S (72), Angeles FSL (73)	Upland Crops
II	Quingua SiL (5), L (109), La Paz FSL (81), FS (77), S (76)	DSR-Peanut GC-TPR-Mung
III	Luisita SL (84), FSL (85), Tarlac SCL (89), Quingua SiCL (285), Umingan SL (100), FS (101), San Manuel SL (96)	DSR-Peanut GC-TPR-Mung
IV	Tarlac CL (86), San Manuel SiCL (94), CL (236), SiL (82), San Fernando CL (67), Annam CL (98), Maligaya SiL (116), CL (117), Bantog SiL (390), Bigaa CL (3), Prensa SiCL (7), Candaba SiL (69), La Paz SiL (78), Umingan SiL (99)	DSR-Mung DSR-Ratoon-Mung
V	Bantog CL (16), San Fernando C (68), Zaragoza C (90), Prensa SiL (66), CL (6), Buenavista SiL (9), CL (8), Novaliches CL (12), Sibul C (14)	DSR-TPR

1) I — Excessively to well-drained, light soils
II — Well-drained, medium-light soils
III — Moderately well-drained, medium-light soils
IV — Poorly drained, medium-heavy soils
V — Very poorly drained, heavy soils
2) DSR — Dry Seeded Rice, GC — Green Corn, TPR — Transplanted Rice
( ) Map code

the potential for upland crop production. The suggested basic pattern is dry seeded rice (DSR) followed by mungbean. A variety of somewhat longer duration than IR36 may be used. If the DSR crop is established early enough and a good stand has been obtained, a ratoon crop may be a profitable venture for a period of 35–45 days after rice harvest, during which it is too wet to plant mungbean.

Suitability Group V This group occupies a large portion of south-eastern Nueva Ecija and the northern and eastern portions of Bulacan. These areas are presently irrigated by large gravity-irrigation systems of NIA (the National Irrigation Administration). A narrow strip of very heavy soil was also identified between Tarlac and Nueva Ecija Provinces.

This group does not limit dry season paddy rice production but would severely limit the production of upland crops. It is suggested that two rice crops be planted on these soils. The first should be dry seeded rice (DSR, IR36) planted in late May after early rains have soaked the soil surface to a depth of 20–30 cm. The second crop should be transplanted rice (TPR, IR36) using 35–40-day-old seedlings. To assure early sowing of DSR the following year, the soils should be rough-plowed following TPR harvest while the soil is still workable, i.e., before it becomes too dry for plowing.

2. *Land-Management Groupings*

Land-management groupings identified from LANDSAT imageries are shown in Fig. 4–b for Pangasinan Province, and in Fig. 5–b for the Tarlac-Pampanga area (area C in Fig. 1).

Management Group I Areas included in this group were considered non-paddy lands. In August the matrix appears to be wet with a few scattered cloudy spots of shallow surface water and very thin vegetation. In Pangasinan, most of these areas are found in flood plains along river banks, especially the Agno river. The same group in the Tarlac-Pampanga area showed very thick vegetation of sugarcane with a few cloudy spots of surface water. A reconnaissance survey of the area made in 1979 revealed that these spots are small groups of paddy fields in lower landscape positions amidst sugarcane plantations.

In general, soils in this group are excessively well-drained which will not puddle readily and therefore are best suited only for upland crops.

Management Group II This group showed a generally wet matrix with many large spots of various size and shape of shallow surface water in the early wet season. In Pangasinan, these areas are located in flood plains usually next to LMG I or immediately along river banks. In August the vegetation is moderately thick (mostly rice) and contains many elongated ribbons of thick vegetation (coconut trees). This group is best represented by the flood plains along the present course of the lower Agno river bank (Abanon and Urbiztondo areas) and along both banks of the Bued river in the vicinities of San Jacinto and Anonang.

Although the distance between these two rivers is considerable, the landuse along them observed by Fukui and Kaida [*ibid.*] is very similar. Both areas are planted to either dry seeded (DSR) or transplanted (TPR) depending on the micro-relief followed by either peanuts, corn, mungbeans, onions or tobacco. In the San Jacinto and Anonang areas tobacco and peanuts are more popular upland crops following DSR or TPR. In some years, green corn (GC) is planted at the onset of the rainy season before TPR in Abanon area.

The recommended cropping pattern for SSG II presented in Table 3 (DSR-Peanut) has already been adopted in the present cropping sequences in many parts of LMG II in Pangasinan. Owing to favorable water regimes in the early wet season, the pattern might be further intensified by planting GC before the main rice crop, followed by a short-duration upland crop, preferably mungbean.

Management Group III The August imagery scene of this group has a well-defined matrix with thick vegetation, a few large spots of surface water (Pangasinan) and many dots of wet patches/surface water (Tarlac-Pampanga areas). This group corresponds to the present and former flood plains of secondary rivers in Pangasinan. A large portion of this group was also identified in the Tarlac-Nueva Ecija and Tarlac-Pampanga areas (along the Bamban and Pampanga rivers) as shown in Fig. 5–b.

The presence of spots and the many dots of surface water indicate that this unit is rich in micro-relief. In the Tarlac-Pampanga areas, sugarcane is dominant on the elevated landforms and rice in the depressional portions where surface water can accumulate. In Pangasinan, the acreage for sugarcane has declined in recent years while rice areas have expanded.

LMG III appears to be wetter than either LMG I or II. Rice can be grown during the wet season without much risk of soil moisture stress, and the soil can be prepared for upland crops after rice earlier and more easily. The present landuse of this group in Pangasinan is transplanted rice (TPR)-Mungbean [*ibid.*]. A more intensive cropping pattern might be introduced in this group similar to that for SSG III shown in Table 3, by planting green corn (GC) before TPR.

Management Group IV In general, the matrix characteristics during the wet season showed a dominance of surface water and a few spots and patches of elongated and/or continuous land units that should belong to either LMG II or III. Except for a few irrigated areas, which are indicated by the presence of spots of surface water in the February scene, this group is mostly bare during the dry season.

In the August scene, the central part of the fluviatile plain (area B in Fig. 1) by the Agno river in Pangasinan (San Carlos area) seems to belong to LMG III. However, the extreme dryness during the dry season as shown in the February scene qualifies it to be classified as LMG IV. The matrix characteristics in the February scene show very dry soil with only a few cloudy spots of wet patches and many ribbons of thick vegetation (coconut trees). At this time of the year the area is almost completely parched and bare [*ibid.*].

There is no double cropping of rice in this area and almost no off-season upland crops in the paddy fields after rice.

3. *Comparison of Soil-Suitability Groups and Land-Management Groups*

Soil-suitability groupings identified from soil survey results, and land-management groupings from LANDSAT imageries are compared in Fig. 4 for Pangasinan Province, and in Fig. 5 for the Tarlac-Pampanga area.

From a comparative evaluation of the two classification schemes the following points emerge:

(1) Annual water regime, which is the decisive factor in designing possible cropping patterns, is reflected directly in the land-management groupings, but only indirectly in the soil-suitability groupings.

(2) In general, the soil-suitability groups (SSG) I to III correspond respectively to the land-management groups (LMG) I to III, and SSG IV & V correspond to LMG IV, with respect to general water regimes, present landuse, and most probably, potential cropping patterns being considered in the IRRI-BPI cropping systems research. The general locations of the corresponding groups are with some obvious exceptions, more or less similar.

(3) Distinct differences were observed in the Tarlac-Pampanga area, as shown in Figs. 5–a and 5–b (area C in Fig. 1). Significant among these differences is the abundance of LMG II and III in areas supposedly of SSG I (non-paddy soils). In most of these areas, especially along the Bamban and Pampanga rivers, where water is available during the wet season, rice is planted rather than upland crops. The matrix characteristics of these areas are very similar to the LMG II and III identified in Pangasinan. A land-classification map prepared by the NIA for the Tarlac-Pampanga area (Fig. 5–c) supports the land-management classification based on the LANDSAT imageries. Land-management groups II and III correspond to the dual-purpose lands in the NIA classification scheme and are planted to rice during the wet season and upland crops during the dry season.

This discrepancy may partly reflect the fact that owner farmers emerging after the Land Reform have expanded rice production mainly for their home consumption in this area that was once a large expanse of sugarcane estates. Rice can be planted in localized relative lowlands where water can accumulate to sustain the crop.

(4) It is difficult to say which classification scheme is more accurate and useful. Delineation of the SSG boundaries can be improved with more detailed soil survey results, and the LMG boundaries may become more accurate and reliable if more LANDSAT scenes are thoroughly investigated with sufficient ground-check surveys. One difference is that the latter scheme is much quicker and easier, and much less expensive.

(5) Though LMG may well be established through careful interpretation of LANDSAT imageries, its usefulness for evaluating potential cropping patterns may be limited by limited numbers of ground-check surveys performed to verify imagery interpretations. Thus, the recommended cropping patterns were related only to SSG in this study.

Summary and Conclusions

Two methods of paddy land-suitability classification for rice-based cropping systems were compared. In one case, soil properties, which are expressions of or which influence field-water regimes, were used to construct soil-suitability groups. These properties are dominant soil texture in the profile, drainage class and organic matter content. Five soil-suitability groups (SSG) were identified: SSG I, non-paddy soils; SSG II, medium-light, well-drained soils; SSG III, medium-light, moderately well-drained soils; SSG IV, medium-heavy, poorly drained soils; and SSG V, heavy-textured, very poorly drained soils.

In the other case, LANDSAT imageries taken at different stages of the cropping season were used to construct land-management groupings, because LANDSAT imageries have been proven to reflect directly water regimes and actual landuse, the most important factors in evaluating rice-based multiple-cropping potentials.

The land-management groups (LMG) correspond more or less to the various soil-suitability groups (SSG), i.e., SSG I has similar characteristics to LMG I, SSG II to LMG II, etc., with respect to water regimes, landuse, and probably the resulting possible cropping patterns. The general locations of corresponding groups are more or less similar, except for some obvious differences.

Field water-regimes cannot be accurately ascertained by using soil properties alone. Soil-suitability groups in the Tarlac-Pampanga areas were reported to contain an extensive area which has very light, excessively well drained soils not suited for paddy rice. However, LANDSAT imagery scenes indicate that many of these areas are utilized for rice production during the wet season.

The results of this study indicate many potential advantages of LANDSAT imageries over the traditional soil survey methods as a means of classifying paddy lands in order to investigate multiple-cropping potential. Conjunctive use of the two classification schemes presented in this paper will improve planning methodologies of evaluating paddy land for rice-based multiple-cropping systems. This study was a start to this end.

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