

PHYSICAL GEOGRAPHY AND RURAL SETTLEMENT PLANNING IN WESTERN JAMAICA¹

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ABSTRACT

Scholten, J. J. 1983 Physical geography and rural settlement planning in western Jamaica. In: J. H. J. Terwindt & H. Van Steijn (eds.): Developments in physical geography – a tribute to J. I. S. Zonneveld – Geol. Mijnbouw 62: 653-658.

In western Jamaica detailed land use planning was carried out between 1977 and 1981 for the development of ten agricultural settlement schemes. The planning process included three steps, i.e. inventory survey, quantitative land capability assessment, and development plan preparation. In this paper the role of physical geography as a basic attribute to the physical planning activities in western Jamaica, is discussed for all three steps.

INTRODUCTION

The aim of this paper is to provide an example of practical use and interpretation of physical geography data in relation to other physical and socio-economic data, in the process of rural land use planning in a part of Jamaica.

In the following, the history and the principles of rural physical planning of a number of agricultural settlement areas in western Jamaica are explained first. Then, the contribution of physical geography information to the various stages of the planning process is indicated in general terms.

PHYSICAL PLANNING OF NEW AGRICULTURAL SETTLEMENTS

In the framework of the land reform programme in Jamaica rural lands have been acquired by the government since 1968 and at an accelerated rate since 1973. Preceding acquisition most of these lands were part of large privately-owned estates which produced a great number of crops such as banana, sugar cane, citrus, etc. The areas concerned were developed and improved for agriculture but recently many estates suffered from neglect because owners lost interest in their upkeep for various reasons. Therefore, when the government acquired these properties, they were often underutilized and production was at fairly low levels. Most of these estates were slated for subdivision into small farms in order to provide farm land to a rapidly growing, largely landless rural population. This meant resuscitation of the agricultural productivity in the areas concerned as well as development of a new physical and

socio-economic infrastructure for a different type of farming, i.e. small farming at an improved, but still fairly low level of management.

Development planning and implementation were rather simple at first. The lands were opened by the construction of farm roads and small villages, followed by the allocation of farm land to applicants in equally large blocks along the farm roads. The size of the farm units was determined at random e.g. five or ten acres (2-4 ha) and the location of farm blocks did not take into account the natural condition of the land. Furthermore, farm units were also planned in thitherto unused or forested lands without sufficient scrutiny whether such lands could indeed sustain agricultural production. It is obvious that due to this approach, which was characterized by an overall lack in organized planning, many problems arose which frustrated both well-meaning government officials and prospective farmer-settlers.

As a result the government was seeking ways to improve the development of rural settlements in a more organized manner, thereby also taking into account the physical capabilities and limitations of the land for various forms of agricultural production. Thus, an improved development policy had to commence with an improvement in detailed rural land use planning and the government established rural physical planning units in each of the four recognized regions of the nation. This was done as part of the decentralization programme of the Ministry of Agriculture. The first of these planning units was set up in 1977 in the western region with bilateral assistance from The Netherlands. This western region includes the four westernmost parishes Hanover, St. James, Trelawny, and Westmoreland. Between 1977 and 1981 ten former estates ranging in size from about 400 to 2000 acres (160-800 ha) were planned in detail for implementation in the western region (*Rural Physical Planning Unit, 1977-1981*; see Fig. 1).

¹ Manuscript submitted: 1983-03-01.

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The preparation of each individual development plan consisted of three stages:

I The first stage comprised an inventory of the natural resources of the development area (topography, physiography, geology, soils, vegetation and rainfall-evapotranspiration characteristics), existing land use and tenure pattern, and physical infrastructure. Also, a review of the residing population and squatter problems as well as a socio-economic questionnaire survey amongst a sampling of candidate settlers was done during this stage.

II Next, in order to determine viable land uses and related farm sizes a *quantitative land capability assessment* was carried out with the objective to find the key to an equal and fair subdivision of the cultivable land into individual farms capable of producing a viable target-income for farmer-settlers. The land capability assessment was done in steps.

(i) In the first step relevant types of agricultural use or Land Utilization Types (LUT's) were defined for each area. The model of these LUT's is a simplified version of the concept of LUT's developed for the Food and Agriculture Organization (FAO) of the United Nations (FAO, 1976). LUT's were selected and defined on the basis of the following criteria: (a) government land use policy towards agricultural production in each area; (b) present land use and agricultural produce in each area; (c) prevailing farm management level and technical knowledge in the wider setting of each area; (d) farm size and land tenure conditions and (e) regional and national marketing aspects. In following this approach, various LUT's were designed such as 'Traditional family-operated dairy farming' and 'Mechanized smallholders irrigated rice farming' and 'Family-operated rain-fed annual crop farming', etc., which are all characterized in terms of their produce (e.g. crops, meat, milk), their level of management (e.g. mechanized, irrigated smallholdings) and related inputs (e.g. fertilizers).

(ii) In the second step quantification of inputs and outputs per LUT was done and maximum productivity levels per LUT per hectare were established expressed by the added-value-factor share (added value in Jamaican dollars is the value of output minus the non-factor costs, i.e. recurrent costs for plant material, livestock, land preparation, liming, fertilizing, etc.)

(iii) In the third step the specific requirements of each LUT were matched with certain existing physical land characteristics in each study area. These land characteristics were inventoried during stage I of the development plan preparation and include characteristics related to the soils, physiography, topography, as well as the local climate including length of growing season for rain-fed crops and risk for flooding. In this matching process individual tracts of land (usually map units of the soil map of the study area) were assigned land capability classes according to physical limitations imposed by the land

characteristics relevant to the various LUT's. For each LUT in a study area six land capability classes (symbolized by Roman numerals I through VI) were distinguished according to the degree of the limitations and their effect on productivity:

Class I land was pegged at 100 per cent of the maximum productivity value, Class II land was pegged at 90 per cent of the productivity value and thus has a 10 per cent reduction in output compared with Class I land, and so on through Class VI land which was pegged at less than 50 per cent of the productivity value. Classes I through V include tracts of land that have potential use (although decreasing in that order from very suited to poorly suited) for the envisaged corresponding LUT, whereas tracts of land which were classified Class VI, i.e. those lands which would produce less than 50 per cent of the maximum productivity value, were considered unsuited for use in the envisaged corresponding LUT.

(iv) In the fourth and final step minimum farm sizes were determined for the individual LUT's for each land capability class. The farm sizes were calculated so that they could generate the target farm income (or target farm-added value) which was established as a matter of government policy. This was done by dividing the target farm-added value by the hectare productivity value of the land capability classes. If for instance, the target farm-added value for smallholdings was pegged at Jamaican \$ 3200 per year and the added value per hectare of Class I land for a certain LUT (e.g. Traditional family-operated dairy farming) was calculated at Jamaican \$ 865 (in 1977) then the corresponding minimum farm size would be $3200 \div 865 = 3.7$ ha. For Class II land the minimum farm size would be $3200 \div (865 - 86.5) = 4.1$ ha, etc. (For more details about this type of quantitative land capability assessment reference is made to ANDRIESSE & SCHOLTEN, 1983).

III The third stage involved the actual *preparation of the physical development plan*. At first, on the basis of the quantitative land capability assessment a separation was made between those tracts of land which have potential for agricultural production (Classes I through V for the various LUT's) and those tracts of land which have limitations that preclude their commercial use for any of the selected LUT's (e.g. very steep land, rock land, that is Class VI land). The non-agricultural areas were set aside for watershed protective vegetation. In the subdivision of all remaining lands that appeared to be suitable for commercial use under any of the envisaged LUT's the results of the quantitative land capability assessment assisted in the design of one or more farm types each capable of producing the target farm-added value. Farm units and roads were then plotted on detailed topographic maps with the aid of the soil and land capability information. The kind of farm plus social considerations determined the placement of farm houses either in small nucleated villages or dispersed on individual farms. (For instance, dairy farming

required placement of farm houses on individual farms with a view to farmer attendance to the farm herd of milking cows and young stock and to minimizing the risk of cattle theft). The need for communal facilities was decided by application of certain rural planning standards with regard to the location of basic schools, postal agencies, health centres, cricket fields, etc. Lastly, electricity and water supply to individual farm houses was dealt with. In the case of electricity supply it appeared possible to extend existing external power lines into all settlement areas.

Extending existing water supply systems to settlement schemes was feasible for the majority of schemes. In three schemes local water sources (springs, streams) had to be tapped and developed whereas in one settlement area no surface source was available. There, a solution had to be found in the repair and enlargement of concreted rain catchments on hill sides feeding local storage tanks and a limited distribution system of roadside standpipes.

PHYSICAL GEOGRAPHY, AN ATTRIBUTE TO RURAL SETTLEMENT PLANNING

Physical geography of western Jamaica

In Table I a summary physiographic description of western Jamaica (approximately 3500 sq km, including the parishes Hanover, St. James, Trelawny, and Westmoreland) is given including general information on the geology, land forms, slopes, soils and hydrology. The soil units are described in terms of Great Groups and Subgroups of the USDA Soil Taxonomy (SOIL SURVEY STAFF, 1975).

The geographic distribution of the physiographic units and land forms presented in Table I is shown in Fig. 1. This figure also shows the approximate location of the ten settlement areas.

The coastal plains make up about ten per cent of the total area, the remainder being uplands. The uplands have a maximum elevation of about 700 m above MSL. Limestone is the prevailing rock type of the uplands and the limestone hills with intervening karst depressions represent the most common physiographic unit in the upland areas. The steep conical hills with sinkholes (locally called 'cockpits') make up a land form of fully-developed tropical karst. The drainage system in the limestone areas is underground with the exception of a few allochthonous rivers and a few streams which are fed by karst springs.

Due to the prevailing northeasterly tradewinds the uplands receive the highest amounts of rainfall (up to 3000 mm annually). The coastal plains along the southern seaboard are located on the leeward side of the uplands. They receive the least rainfall of the region (1500-2000 mm annually). Most of the rainfall is concentrated during the period from April through November. These months are the growing period for rain-fed annual crops. December through March are relatively dry months but nearly everywhere monthly rainfall still exceeds 60 mm during this period. However, due to the occurrence of dry spells during this period annual crops can only be grown successfully with supplementary irrigation. Tree crops can be grown throughout the year without irrigation. The cultivation of wetland rice on the coastal plains requires a system of flood irrigation throughout the year in order to allow for a complete water control on the paddies. Due to its location at about 18°

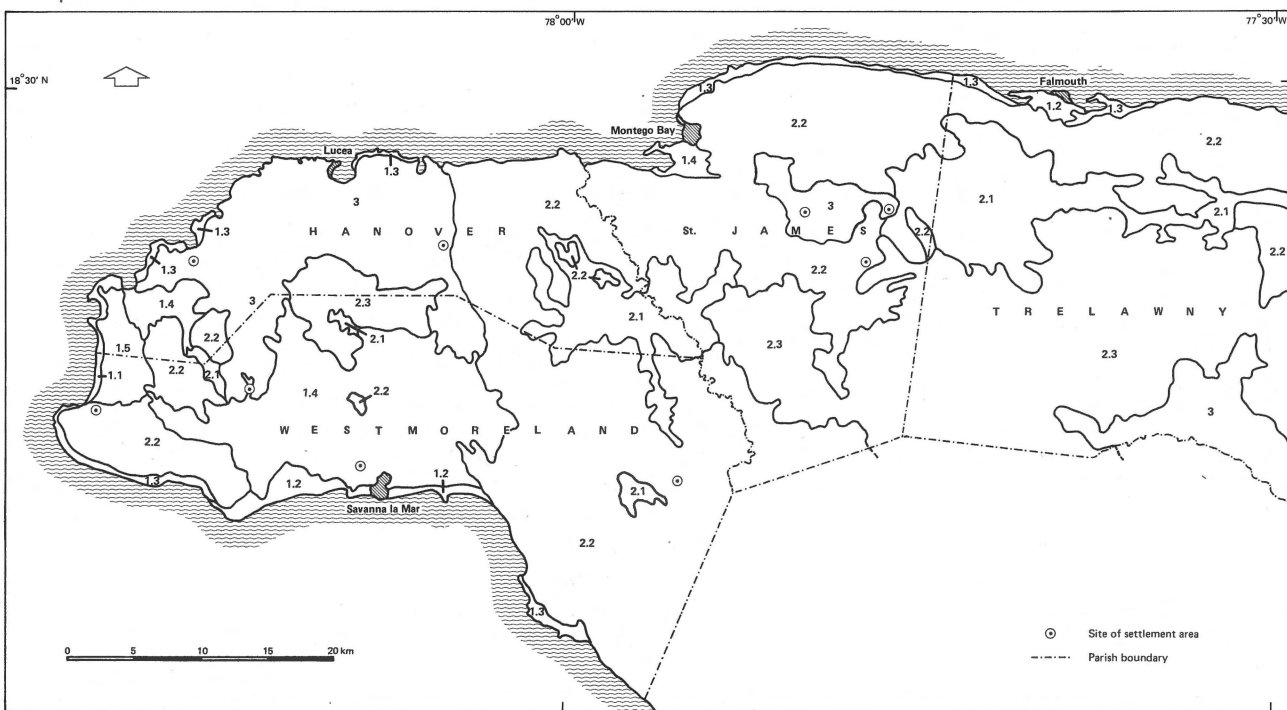


Fig. 1 Physiographic units and land forms of western Jamaica (For explanation of map unit symbols, see Table I).

Table I
Physiographic units of western Jamaica and description of associated characteristics

Major physiographic unit (% of total area)	Map unit number	Land form	Geology	Slope	Soils	Hydrology
1. Coastal plains (10%)	1.1	Beaches, sand bars	Coastal sands	0-2°	Tropopsammets	Brackish groundwater
	1.2	Recent tidal clay flats and beach ridges	Recent tidal deposits	0°	Hydraquents Tropaquents Sulfaquents	Frequent flooding with saline or brackish water
	1.3	Raised coral reefs	Coralline limestone	0-2°	Lithic Troporthents (Sulfic)	Brackish groundwater
	1.4	Plains with limestone outcrops	Old tidal and recent alluvial deposits underlain by limestone	0-2°	Tropic Fluvaquents, Tropaquents, Tropofluents, Eutropepts	Brackish to fresh groundwater at shallow depth, flooding with brackish to fresh water
	1.5	Peat marshes	Peat overlying clays	0°	Tropohemists, Sulfihemists	
2. Karst uplands (75%)	2.1	Plateaux with sink-holes	Limestone with variable chert contents	0-7°	Palehumults, Paleudults	Subterranean drainage, few allochthonous streams, few karst springs, (intermittent) ponds
	2.2	Hills with intervening karst depressions and sinkholes		upto 40°	Lithic and Typic Tropudalfs, Lithic Argiudolls	
	2.3	Steep conical hills with sinkholes (cockpit country)		upto 45°	Lithic Tropudalfs Lithic Troporthents	Subterranean drainage, few springs
3. Uplands (15%)	3.	Hills with narrow flat-bottomed valleys	Shale, andesitic tuff	upto 25°	Tropudalfs, Tropudults and some Eutropepts, Tropofluents	Surface drainage with springs and streams

N and a low to medium elevation mean daily minimum and maximum temperatures range from about 20° to 28° C. Absolute minimum temperatures may be as low as 15° C during January, February, and March.

Physical geography in the planning process

Information of a physical geographical nature was used during all three stages leading to the preparation of development plans of new agricultural settlements.

In the first stage the description and recognition of land forms was a prerequisite in attaining a proper understanding of the topography and soils of each area. Boundaries between land forms usually coincide with soil boundaries because a change from one land form to another usually means a change in the complex of slopes and may include a change in soil parent material, occurrence of rock outcrops, soil drainage class, susceptibility to flooding, and vegetation patterns. A good example of the relationship between land forms and soils in a part of western Jamaica (and subsequent implications for land use planning through the process of land capability assessment) is presented by ANDRIESSE & SCHOLTEN (1983) in a paper on land capability assessment of one of the ten settlement schemes (Burnt Ground) in western Jamaica. This

settlement scheme is located in an area including elements of map units 2.1 and 2.2 of Fig. 1: an undulating to rolling limestone plateau with deep, well-drained and strongly weathered soils (Figs. 2 and 3) bordering on steep limestone hills with shallow, well-drained stony soils and many limestone outcrops (Fig. 3).

In another interesting section of the region the settlement scheme of Meylersfield (*Rural Physical Planning Unit, 1977-1981*) is located in map unit 1.4 in the parish Westmoreland (Fig. 1). There, old tidal and recent alluvial deposits with inclusions of small peat areas occur on a plain with scattered small limestone outcrops. Each of these minor land forms that make up the coastal plain could be discerned by means of a combination of airphoto interpretation and field survey. In the field clear relations between the land forms and specific soils could be established, e.g. old tidal flats having poorly drained, saline potential acid sulphate soils with low bearing capacity; river levees with somewhat poorly drained, nearly ripe alluvial clay soils; peaty depressions with very poorly drained peat soils; and low limestone outcrops with shallow, well drained, stony soils.

With a view to the close relationship between land forms and soils as indicated above, specific vegetation and land use

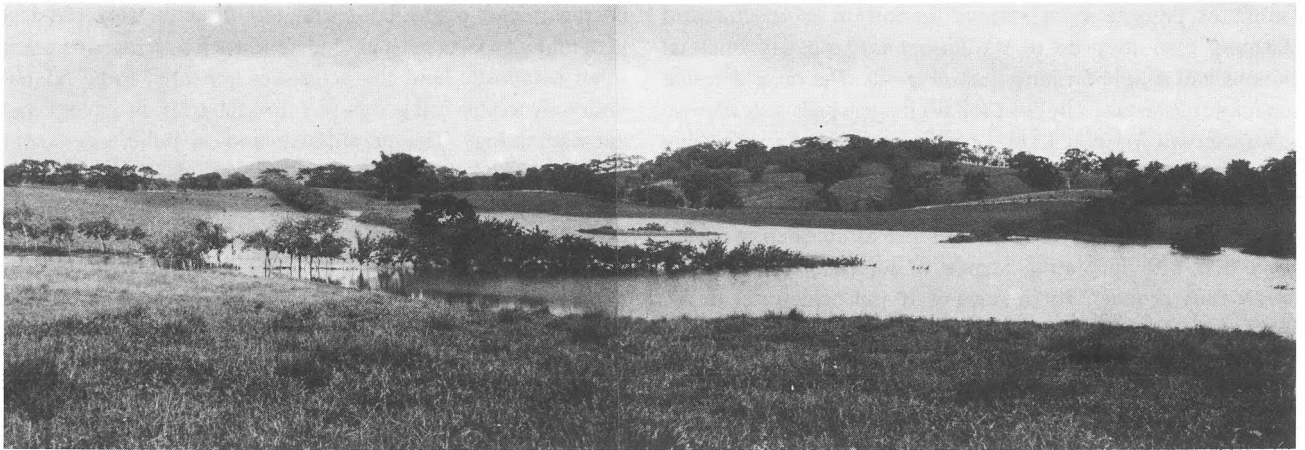


Fig. 2
Flooding by rainfall in a depression on a rolling limestone plateau, Burnt Ground settlement scheme, parish Hanover.

patterns could be identified in association with individual land forms and position in the landscape.

The study of land forms also provided an insight in the presence of interesting quantities of materials (such as marl, gravel and sand) which could be used in road construction and other engineering activities.

In the second stage which dealt with quantitative land capability assessment, physical geography data played an essential role in the delineation of those physical land characteristics which have diagnostic significance to land capability due to their limiting influences on agricultural productivity within individual LUT's. Most of these diagnostic land characteristics or limitations could be quantified by measurements in the office (e.g. slope maps from topographic maps with contour lines), field, and laboratory. They include (a) limitations which are directly conditioned by physical geography aspects and (b) limitations which are indirectly related to physical geography aspects:

(a) *limitations directly conditioned by physical geography aspects*

- slope affecting susceptibility to erosion and potential for soil conservation treatment

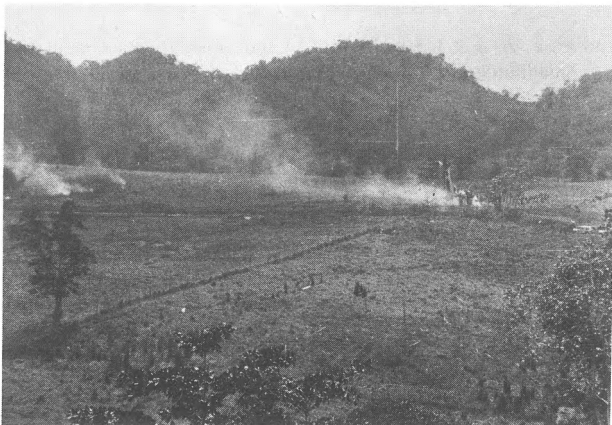


Fig. 3
Undulating limestone plateau with deep soils and in the background limestone hills with shallow, stony soils near Burnt Ground settlement scheme, parish Hanover.

- rock outcrops restricting effective soil surface and land management
- occurrence of gullies restricting effective soil surface and land management
- flooding adversely affecting crop and pasture performance through physical damage and lack of oxygen (Fig. 2).

(b) *limitations indirectly related to physical geography aspects*

- effective soil depth or depth to hard bedrock or peat layers or acid sulphate soil layers
- soil stoniness restricting availability of moisture and nutrients as well as soil workability (Fig. 4)
- soil acidity adversely affecting soil fertility
- poor soil drainage adversely affecting crop performance due to waterlogging
- salinity adversely affecting crop and pasture performance
- length of growing season affecting the number and kind of crops which can be grown annually under rain-fed conditions.

The ranges of these limitations change from one LUT to another. For instance soil depth is a more serious limitation to crop farming than to dairy farming and rock outcrops and soil

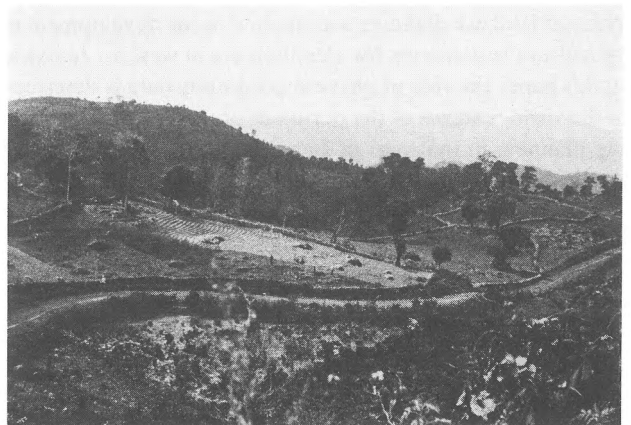


Fig. 4
Limestone hills with clearings for annual rain-fed crops, Leamington settlement scheme, parish Westmoreland. The problem of soil stoniness (chert fragments) is partly alleviated by stone picking and incorporation of stones in piles and walls.

stoniness present more serious limitations to mechanized farming than they do to traditional farming with manual labour and simple farming tools (Fig. 4). The most extreme example is presented by poor soil drainage which is an adverse characteristic for most LUT's except for wetland rice farming LUT's which require soils that can be inundated easily.

Within individual LUT's ranges in values of the diagnostic land characteristics or limitations were established in such a way that with increasing degree of limitation they reflect decreasing productivity in steps of 10 per cent (refer to the section on physical planning of new agricultural settlements). Some relations between physical limitations and productivity levels are simple. For example, the effect of scattered rock outcrops and gullies on production is directly dependent on the area they occupy. In the case of slope, the degree of the original slope determines the area occupied by the risers between bench terraces and thus the loss in cultivable area following soil conservation treatment. Other relationships are more complex and difficult to quantify and for such limitations (e.g. soil acidity) ranges were assessed on the basis of available data from local research stations, farm records or simply on assumptions.

In the final stage of planning the alignment of farm and forest boundaries, roads, water- and electricity supply lines as well as the internal lay-out of farms (e.g. bench terracing) were dictated to a large extent by the natural setting and make-up of the landscape, i.e. its physical geography.

Some settlement schemes could not be linked up with existing water supply systems due to prohibitive distance to or insufficient capacities of such systems. These settlement schemes had to be supplied from local sources. In shale areas surface water is available in sufficient quantities from streams and springs. In limestone areas surface streams are usually absent and groundwater unreliable or too deep. There, karst springs form the only possible source of water.

CONCLUSIONS

Physical land use planning was applied in the development of agriculture settlements for smallholders in western Jamaica. In this paper the role of physical geography data is described in the various stages of the pertinent process of physical land use planning in that part of Jamaica. In the inventory stage physical geography data contributed to the execution of soil surveys and the gathering of other physical environmental information. In the next planning stage which dealt with quantitative land capability assessment, certain existing physical land characteristics were matched with the specific requirements of individual types of agricultural use or Land Utilization Types (LUT's). This was done because these 'diagnostic' land characteristics present limitations to the agricultural productivity of LUT's. Some diagnostic land

characteristics could be correlated directly with physical geography aspects such as slope and rock outcrops, whereas other diagnostic land characteristics appeared to be related indirectly to physical geography through soils, hydrology and agroclimatology. The quantitative land capability assessment indicated which tracts of land have potentials for the different types of agricultural production and which areas have no potentials. Also, minimum farm sizes could be calculated in relation to selected LUT's. Once this information was available, the third and final stage of the rural settlement planning could be implemented and the various elements of the physical development plan (e.g. farm and forest boundaries, roads, water and electricity supply lines etc.) could be plotted on topographic base maps on the basis of the setting and the natural features of each study area, that is its physical geography.

ACKNOWLEDGEMENTS

I acquired a lasting interest in physical geography when I studied under the guidance of Prof. Dr J. I. S. Zonneveld at the State University of Utrecht. The teachings of Prof. Zonneveld served me very well during many assignments with development assistance projects in the tropics. The information for this paper was collected during my three years' assignment as a Netherlands bilateral assistance expert with the Rural Physical Planning Unit of the Ministry of Agriculture, Western Region, Jamaica.

I wish to acknowledge the assistance of the following persons in the preparation of this paper: Mr W. Andriesse (Stichting voor Bodemkartering, Wageningen) for drawing Fig. 1 and Mrs C. Smit for typing the manuscript.

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