



**GUIDELINES FOR WRITING THE CHAPTER ON LAND EVALUATION
IN SOIL SURVEY REPORTS**

- by -

**Land Evaluation Section Staff
(April 1989)**

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**MINISTRY OF AGRICULTURE
RURAL PHYSICAL PLANNING DIVISION
JAMAICA SOIL SURVEY PROJECT**

SUMMARY:

A standardized format for the chapter on land evaluation in Soil Survey Reports, which are to be issued by the Soil Survey Project of the Rural Physical Planning Division, is discussed in this Technical Guide. Sections which have to be specifically prepared for particular survey areas are indicated in the text.

This report is the seventh in a series of Technical Guides issued by the Jamaica Soil Survey Project (JM/89/001), a bilateral undertaking of the Governments of Jamaica and the Netherlands. It was prepared by Niels H. Batjes. Technical Guides are meant for internal use.

OBJECTIVE

This Technical Guide provides a standardized format for writing Chapter 5, which includes the agronomic interpretation of survey data, in Soil Survey Reports.

The numbering of paragraphs and tables in this Guide is according to the sequence used in Soil Survey Reports.

Three sections of this "standard text" should be modified to suit local conditions prevailing in a particular survey area, namely:

*Section 5.3. Land land utilization types

*Section 5.8. Assumptions

*Section 5.9. Results and recommendations

General guidelines, pertaining to the compilation of said sections, are highlighted in the text using the following format: [....].

The general assumptions (Section 5.3-5.8) are not to be changed because they are programmed in the JAMPLES software (see TB-15).

Definitions of technical terms such as land characteristics, land qualities, land utilization types (FAO, 1976) should be explained in the Glossary.

In view of speeding up the writing/compilation of survey reports a copy of this proposal will be prepared for the Apple MacIntosh using Microsoft Word. Copies of this master-file can easily be merged into soil survey reports which are in preparation.

GENERAL FORMAT FOR THE CHAPTER ON LAND EVALUATION
IN SOIL SURVEY REPORTS OF SSU/RPPD.

5. AGRONOMIC INTERPRETATION OF SURVEY DATA

5.1 Introduction

During a soil survey data about the soil and land resources are collected. These data have to be interpreted for the user of the soil map and report. This can be done in several ways. In the former Soil and Land Use Surveys (RRC, 1958-1970), the "Land Capability Classification System" of Klingebiel & Montgomery (1961) was used. This system allows for the identification of the arable acreage, but not for the identification of specific land use recommendations. This shortcoming of the Land Capability Classification System has been duly recognized since the Soil and Land Use Surveys include tables of 'recommended crops for soils'.

Since 1986, land use performance is assessed using the Jamaica Physical Land Evaluation System (JAMPLES). This software package was developed by Soil Survey Staff (see SSU, 1986, 1989a & 1989b) using the general principles and procedures of the "Framework for Land Evaluation" (FAO, 1976). Fundamental to the "Framework" approach is that the evaluation of land use performance is only meaningful in relation to a clearly defined use.

5.2 Methods

The JAMPLES procedure includes four main stages:

Stage 1 - Data gathering and storage: Data on climate, soils and topography (land characteristics) as well as agro-ecological crop requirements (land use requirements) collected during the soil survey are stored in the computer.

Stage 2 - Data analysis: The land evaluation process starts with the selection of the relevant land utilization types (LUT), each of which has specific land use requirements (Section 5.3 and 5.4). Land characteristics, which are single attributes of land, are used to rate the land qualities of specific land units (Section 5.5). Subsequently, land qualities are matched with land use requirements (Section 5.6). First, the current limitations of a land unit for a particular crop are determined. Subsequently, the computer assesses which of these limitations can be solved through land improvements. The technical and socio-economic setting specified for the land utilization type determines which land improvements can be implemented (Section 5.3 and 5.8). Finally, the computer prints tables with the provisional land suitability classification.

Stage 3 - Interim validation of results: During this critical stage provisional results are checked and validated against

field observations (ground truth).

[Elaborate where possible, for instance by including references to results of agricultural research carried out in the survey area or in locations with similar agro-ecological conditions.]

Stage 4 - Recommendations: Suitability classifications of individual land units for specific LUTs are shown in tables and discussed (Section 5.9). This information can be used by planners and agriculturists who have to identify and/or recommend feasible land use alternatives for the study area. The assumptions should be carefully read before implementing the recommendations (Section 5.8).

5.3 Land utilization types

The potential suitability of a land unit for a specific crop varies with the level of technology and capital-intensity available to the farmer and his management skill. The actual suitability is further determined by socio-economic factors, including Government policy towards agricultural production.

Many types of agricultural land use exist in Jamaica (CRIES/RPPD, 1982). In view of this complexity, land utilization types (LUT) are defined as management systems which produce a particular crop in a defined technical and socio-economic setting. This setting is described under the general heading "major kind of land use" (MLU).

Each LUT is identified by a unique code, for instance "MLU-B/yam" (see Section 5.9). Table 5.1 shows which combinations of MLUs and crops are considered to be relevant for the study area.

Table 5.1 Land utilization types (MLU/crop systems) considered relevant for the survey area.

Crop Name	Management system			
	MLU-A	MLU-B	MLU-C	MLU-D
crop-1 (e.g. maize)	+	+	+	+
crop-2	-	+	+	+
unimpr. pasture	+	-	-	-
crop-n	-	-	-	+

* Relevant LUTs are indicated with a '+', otherwise a '-' is shown.

Four MLUs are considered in this land evaluation:

[The descriptions of the technical and socio-economic settings (MLU) should be refined to suit local conditions prevailing in the survey area but this without changing the technical assumptions postulated in SSU (1989a). Ideally, this exercise should be carried out in collaboration with an experienced agricultural economist.]

MLU-A: Mixed, non-commercial (subsistence) rainfed farming based on low technology and low capital-intensity.

Land use is of a permanent nature on holdings of less than x hectare each [x: acreage to be specified by the user]. Each holding consists of several small plots which occur generally over a larger area. Capital intensity of farmers is low, limiting physical inputs to land clearing, burning and shallow tillage before sowing or planting. All field activities are carried out manually, the main tools being the spade, fork and machete. Weeding practices are generally at a low level as are erosion and drainage control. Manure, where available, is used to correct/maintain the nutrient status of the soil but chemical fertilizers and lime are seldom applied. And this, mainly as a result of economic constraints. Hence the need for a fallow period to regenerate the soil fertility status.

Local varieties of annual, perennial and tree crops are grown in a mixed cropping system. A limited number of climatically adapted tree crops is grown on the homestead. Average yields remain low at the prevailing level of technology/capital-intensity. Farmers are mainly without formal education. They follow traditional methods and show little inclination towards change if such changes involve taking risks. Support from the Extension Service is needed.

MLU-A includes activities such as the rearing of local breeds of goats and pigs on marginal land or of chicken and rabbits on the homestead, while bee-keeping is practiced by some farmers. The produce is mainly used for subsistence but occasional surpluses are sold on the local market.

MLU-B: Mixed, commercial (rural market oriented) rainfed farming using intermediate technology and intermediate capital-intensity.

Land tenure is of a permanent nature. Farm size varies from x to y ha and plots are somewhat fragmented. Technology and capital intensity are at intermediate level. Cultivation is sometimes mechanized but most field maintenance practices are carried out manually. Soil drainage works are seldom used whereas simple soil conservation measures are common practice. Weeding is done by hand and commercial pesticides are used. Other physical inputs

include liming, manuring and the application of fertilizer. The rate, kind and application of chemical fertilizers is not based on crop and soil specific recommendations. As a result, only simple nutrient deficiencies and toxicities can be remedied under good management.

Most farmers have at least primary schooling. They are willing to adopt improved methods where benefits can be clearly demonstrated. Detailed recommendations on agronomic practices are provided by the Extension Service.

MLU-B is mainly based on a mixed cropping pattern, but in some small fields annual crops are grown in pure stands. Mainly local crop varieties are grown. Simple moisture control measures are taken to optimize rainfall efficiency for crops.

The produce is mainly sold at rural markets. MLU-B requires adequate marketing facilities and good infrastructure.

MLU-C: Mixed, commercial (rural/urban market oriented) rainfed farming with supplementary irrigation under intermediate technology and intermediate capital-intensity.

Land tenure is of a permanent nature. Farm size varies from x to y ha and plots are mainly clustered. Management, technology and capital intensity are at intermediate level. Cultivation is often mechanized but some field maintenance practices are carried out manually. Moderate use is made of drainage works and soil conservation practices. Most weeding is done by hand but commercial pesticides are used. Other physical inputs include liming, manuring and the application of fertilizer. The rate, kind and application of fertilizers is based on general recommendations for particular crops but they are not soil specific. As a result, only simple nutrient deficiencies and toxicities can be corrected under good management.

MLU-C mainly differs from MLU-B in that it uses supplementary irrigation (mainly furrow and/or sprinklers). The irrigation facilities allow farmers to remedy possible periods of water shortage during the rainy season - enhanced risk security - but the irrigation capacity is not adequate for year-round irrigation.

Most farmers have at least primary schooling. They are willing to develop and adopt improved methods. Detailed recommendations on agronomic practices are provided by the Extension Service based on results of agricultural research.

The system is based on a single cropping pattern and sound crop rotation. Local and high yielding crop varieties are produced, mainly to be sold at rural and urban markets. This MLU requires good marketing facilities and infrastructure.

MLU-D: Commercial (urban/export market oriented) rainfed/irrigated farming based on high technology and high capital intensity.

Land tenure is of a permanent nature. Farms are mainly large (x-y ha) and consist of contiguous plots. They are operated by highly skilled managers, who often have a degree or diploma in agricultural education. The level of capital intensity, technical know-how and management is high. Field operations (e.g. cultivation, sowing, fertilizer application, spraying) are predominantly mechanized, but manual labour is used at harvesting. Irrigation (i.e. furrow, sprinkler or drip) is widely used in areas or periods of low rainfall, resulting in a high demand for a reliable supply of good quality piped water. Adequate use is made of drainage works and soil conservation practices. Pesticides, herbicides and inorganic fertilizers are widely applied using site specific recommendations.

Physical soil characteristics are the main source of limitations at this level of technology. "Moderate" limitations related to impeded drainage are solved through artificial drainage. Limitations of a chemical nature can be remedied in MLU-D except for salinity and sodicity. For the latter, improvements are not considered economically viable (e.g. reclamation of saline/sodic soils).

Modern farming and marketing techniques are used to maximize yields and economic returns. This includes the growing of high yielding crop varieties in pure stands and in agriculturally sound rotations. In case of irrigated pastures, beef and dairy are the main produce. All produce is sold at the urban market or exported. This makes a good infrastructure necessary.

5.4 Land use requirements

FAO (1976) defines land use requirements as the set of conditions necessary or desirable for the successful and sustained operation of a given land utilization type.

The set of land use requirements related to the efficient functioning of a particular LUT includes:

a) Crop requirements.

Physiological requirements vary from one crop to the other and also between crop varieties. For a particular crop, there will be a difference between the physiological requirements for minimum and optimum growth. Crop requirements are mainly derived from international sources and complemented with Jamaican expertise (see SSU 1989a).

b) Management requirements.

Each type of LUT has specific management requirements which are a result of the technical and socio-economic setting

described for the MLU (see SSU 1989a).

c) Conservation requirements.

JAMPLES determines whether a land unit is physically suitable for the sustained application of a LUT. The absence of risk of environmental degradation is therefore considered as a land use requirement.

5.5 Land qualities

Each land unit is characterized by single attributes, called land characteristics, which are recorded/measured during the field survey and laboratory stage. Table 5.2 shows how land qualities are described using one or more land characteristics. For example, the land quality of "moisture availability" to a particular crop is rated using the land characteristics rainfall, potential evapo-transpiration and soil moisture retention.

The land quality ratings are derived from land characteristics using the rating system developed by Soil Survey Staff (SSU, 1987b). Land qualities are complex attributes of land which act in a manner distinct from the actions of other land qualities in their influence on the suitability of land for a specified use (FAO, 1976). For convenience, they are grouped into two categories based on their general effect on crop productivity, viz.:

a) Land qualities related to agro-ecological conditions:

- soil moisture regime (MR)
- air temperature regime (TR)
- soil reaction (PH)
- nutrient retention (NR)
- nutrient availability (NA)
- calcium carbonate toxicity (CC)
- aluminium toxicity (AL)
- salinity hazard (SA)
- sodium toxicity (SO)
- availability of oxygen in root zone (OX)
- rooting conditions (RC)

b) Land qualities related to water and land management:

- absence of a long term erosion hazard (E)
- ease of cultivation (workability, W)
- irrigability of the land (I)

5.6 Matching of land qualities with land use requirements

During the matching process the land qualities of a particular land unit - characterized by its major soil(s) - are compared with the land use requirements of individual LUTs. The matching procedure calculates the factor ratings. Each factor rating

indicates the degree in which a particular land use requirement is satisfied, under current conditions, by the corresponding land quality.

Table 5.2. Land qualities and associated land characteristics as considered in JAMPLES.

Land qualities	Land characteristics
Moisture availability	monthly rainfall; monthly PET; available water capacity of soil
Temperature regime	air temperature
Nutrient retention capacity	effective cation exchange capacity (ECEC) in upper 30 cm
Soil reaction	pH-H ₂ O (1:2.5) in upper 50 cm
Nutrient availability	Exchangeable Ca, Mg and K (1M NH ₄ OAc at pH 7); organic matter content; available Phosphorus (Truog) in upper 30 cm. [Also: pH, salinity, sodicity, CaCO ₃ and Al]
Ca-carbonate toxicity	CaCO ₃ content in upper 50 cm
Aluminum toxicity	percentage of ECEC saturated with exchangeable aluminum in upper 50 cm
Excess of salts	Electrical conductivity in saturated paste; depth of occurrence of salts within 100 cm from the surface
Sodicity hazard	Exchangeable sodium percentage (ESP) in upper 50 cm.
Availability of oxygen	soil drainage class
Ease of rooting	Soil depth to physical root limiting layer; drainage class; stoniness/rockiness; porosity; vertic properties
Erosion hazard	soil texture; soil structure; organic matter content; slope angle and length; rainfall erosivity; present vegetation cover
Ease of cultivation resp. mechanization	consistence; stoniness and/or rockiness; soil depth; slope angle; ESP
Ease of irrigability	available water capacity; soil permeability; slope angle; monthly rainfall

Three factor ratings, or classes of limitation, are recognized in JAMPLES (see Appendix *), viz.:

- 0: not/slightly limiting (i.e. very high grade of availability/absence of risk of land quality for specified crop under current conditions)
- 1: moderately limiting
- 2: strongly limiting

The above classes of limitation correspond with an anticipated yield reduction of less than 20%, 20 to 50% and over 50% from targeted yields respectively.

5.7 Land suitability classification

The potential suitability of a tract of land for a particular crop varies with the technical and socio-economic setting (MLU) in which the crop is produced. The land suitability classification is derived from the factor ratings, taking into account those land improvements that are practicable for the specified MLU (see SSU, 1989a).

The output of JAMPLES is checked by the soil surveyor, who uses the agricultural expertise available for the study area, before final recommendations are made (Section 5.9). The land suitability classification system is discussed below.

Two land suitability orders are considered in JAMPLES in accordance with the format proposed in 'A Framework for Land Evaluation' (FAO 1976), viz. suitable (S) and not-suitable (N). Classes within orders are indicated with numerals which reflect the respective degree of suitability of the land for the specified land use.

Four land suitability classes are recognized in JAMPLES (see Table 5.3), viz:

- Highly suitable (S1): This type of land has no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity and will not raise inputs above acceptable levels. In most years, the specified crop will produce from 80 to 100 percent of the targeted yield.

- Moderately suitable (S2): This type of land has limitations which, when combined, are moderately severe for sustained application of a given use. The limitations of the land will reduce productivity and increase required inputs to the extent that the overall advantage to be gained from the use will be appreciably lower to that experienced for S1 land, but the inputs will be satisfactorily covered by the returns. In most years, the considered crop will produce from 40 to 80 percent of the targeted yield.

- Marginally suitable (S3): When land is rated as S3 its aggregate limitations are severe for sustained application of a given use. Productivity will be so reduced that the inputs will be only marginally covered. In most years, the specified crop will produce from 20 to 40 percent of the targeted yield.

Land on which a crop produces less than 20 percent of the targeted yield in most years is termed not-suitable. It can either be currently not-suitable, i.e. have limitations that are so severe so as to preclude successful sustained use of the land in the given manner, or permanently not-suitable, that is show no potential for sustained agriculture irrespective of the type of land improvements.

The class "not-relevant" is used when a particular land use is not pertinent within the socio-economic context of the study area.

Table 5.3. Agro-ecological land suitability classes determined with the land evaluation module (LANDEV).

Order	Suitability Class	expected % of targeted yield
S: suitable	S1: highly suitable	80 to 100%
	S2: moderately suit.	40 to 80%
	S3: marginally suit.	20 to 40%
N: not-suitable		0 to 20%

Suitability subclasses are indicated with common letters where the land suitability for a specified use is either S2 or S3. Each letter reflects the nature of a major limitation for the envisaged land use. Additional insight with regard to the nature of these limitations can be derived from Appendix *. Where relevant, subclasses are indicated in the output tables (see Section 5.9) using small letters:

- t: air temperature limiting for the crop under consideration.
- w: high rainfall is a constraint for good production (explain in report)
- r: rainfall low and highly variable thereby limiting growth of the specified crop (MLUs A and B)
- f/p: unfavourable soil/terrain conditions after land improvement. Only the most stringent condition is indicated: f for soil fertility and p for physical/topography related constraints.
- e: risk of soil erosion under sustained application of the indicated use.

[The following example should be relevant for the study area]

The classification system is explained using an example. A land unit that rates as being S2e for the LUT MLU-B/Coffea arabica is moderately suitable (S2) for this land use alternative. The main problem for the sustained and successful production of coffee at the specified level of technology and capital-intensity (MLU-B) is the risk of land degradation through erosion (e).

5.8 Main assumptions

This land evaluation study is based on a number of assumptions which should be read before using the results (Section 5.9), viz:

[Include only those assumptions which are relevant for the study area. Also indicate "special" assumptions that are relevant for the area under consideration.] ×

- Land suitability is determined for sustained agricultural use (long term productivity).
- Sound crop rotations and good management skills are used to maintain sustained productivity. Such rotations reduce the incidence of diseases and pests and optimize the efficiency of fertilizer application and irrigation.
- The cost of solving strongly limiting conditions of soil salinity, sodicity and drainage is assumed to be prohibitive within the prevailing socio-economic context. Minor limitations (factor rating = 1) for drainage, however, can be solved for MLU-D.
- Rainfed farming of a particular crop is not recommended in areas where the risk of crop-failure resulting from conditions of "drought" exceeds 25 percent during the envisaged growing season (MLUs A and B).
- An adequate supply of water of good quality and the existence of a good distribution system are assumed when rating land suitability for irrigated crops (MLUs C and D).
- The targeted (or optimum) yield of a particular crop changes with the technical and socio-economic setting in which it is produced. That is, it generally increases as the level of technology increases. This aspect can be illustrated using data adapted from ILACO (1981). The "targeted" yield of rainfed maize in the tropics is about 1 to 1.5 metric tonnes/ha for MLU-A, 2.5-3.0 metric tonnes/ha for MLU-B and 4.0-5.0 metric tonnes/ha for MLU-D.

- For most crops it is not yet feasible to quantify yield depressions which result from partial deficiencies of specific land qualities, due to a scarcity of relevant research data.
- Year to year variations in yields, which are due to the variability in space and time of rainfall, can be in the order of 40 percent for rainfed crops and 20 percent for irrigated crops (ILACO, 1981, p. 518).
- At the present scale of mapping, small areas of "minor" soils are included in each mapping unit (see Section 3.*). The response of these "included" soils to land management practices, and hence their suitability for a given use, can differ from that of the major soils. Land suitability recommendations in this study are for the major soils only! Hence, there is the need for on-site checking of soil conditions before developing a tract of land into a particular land use. When the development of modern farms is envisaged, the field investigations should be followed by crop variety and fertilizer trials. Trial plots provide farmers and investors with an insight into soil-water-crop relations allowing for cost analysis (pre-feasibility study).
- JAMPLES is the first stage of a "two stage" approach to land evaluation. The recommendations are mainly based on the analysis of agro-ecological factors. Socio-economic factors, however, will further determine the "actual" suitability rating. The availability of a market for the produce, quality of the produce, price of the produce, incidence of praedial larceny and adequacy of infrastructure are some of the socio-economic factors that strongly determine the "actual" viability of a LUT.

5.9 Results and recommendations

[The contents of this section will differ for each survey area. Land evaluation results should be presented in a format which is readily accepted by the end user. This involves the preparation of summary tables showing land suitability classifications for the specified agricultural uses (Table 5.4-5.*). These tables are prepared manually so as to ensure that the writers of reports thoroughly check results generated by the computer before they are released as recommendations to end users. The main findings should be summarized in Section 5.9, making reference to the relevant table (see e.g. Soil Survey Report No. 2.).

Ideally, land suitability maps with tabular legends should be prepared for each LUT. The number of LUTs considered in JAMPLES, however, often precludes the compilation of such maps.

In the case of compound soil mapping units, for instance complexes, symbols on the land suitability map should reflect the respective land suitability classifications of the major component soils.]

Table 5.4. Suitability of selected land units for specific land utilization types. [*]

LAND UNIT			LAND UTILIZATION TYPE			
Soil map unit code	major soils	slope phases	crop-1	crop-2	...	crop-n
PR1	Whim	0-2%	S1	S1		S2f
BOx4	Linstead	0-5%	S1	S2p	...	S3p
	Rosemere	2-5%	S2f	S3f	...	N
HLx1	St. Ann	8-16%	S2e	S2e	...	S3e
	Bonnygate	16-30%	S3e	N	...	N
	Rockland	16-50%	N	N	...	N

[One table should be prepared for each technical and socio-economic setting (MLU). Recommendations should always be made on a soil map unit basis. End this section with the following paragraph.]

This study does not provide any statement of the desirability of one type of land use as compared to another. Physical land evaluation is mainly concerned with the assessment of land resources (climate, terrain and soils) with a view to determine technically feasible land use alternatives. The selection of the most promising use is the task of the planner, who has to base his selection on socio-economic and political factors as well. Economic feasibility analyses are beyond the scope of this report.

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