Technical Specifications and Contracting Requirements

Regional Disaster Vulnerability Reduction Projects

Consultancy Services for the Design and Development of Specifications and Scope of Service for, and Supervision/Quality Control of Soil Survey

EcoApp Inc.
An Ecosystems Approach

THE WORLD BANK

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Table of Contents

1 Background to Terms of Reference

1.1 Introduction

The Government of Grenada (GoG) has secured financing arrangements with the World Bank, the proceeds from which will be allocated towards the financing of the Regional Disaster Vulnerability Reduction Project (RDVRP). The Support from the Pilot Program for Climate Resilience (PPCR) and World Bank under the RDVRP is aimed at providing Grenada with financial and technical assistance to reduce vulnerability to natural hazards and climate change impacts. Among the specific aims of the project are the goals to integrate disaster vulnerability reduction and climate resilience in national development strategies and management of public infrastructure.

Soils provide a range of essential ecosystem services that support plant and animal life and regulate environmental quality. However, increasing anthropogenic interference and climate change impacts are causing unprecedented forms of soil and land degradation including, landslides, soil erosion and loss of soil fertility This is affecting the capacity of the soil resources in Grenada to carry-out their functions sustainably. Grenada's last soil survey, produced in 1959, is outdated. Additionally, the classification system used is antiquated and incompatible with current internationally accepted classification systems.

Among the project deliverables of the RDVRP is a comprehensive soil survey of the country, and to carry out several other activities that will help optimize its long-term value. This includes upgrading of the facilities and capabilities of the Land Use Division of the Ministry of Agriculture that will be required to use and update the generated soil survey data.

In view of the complexity of the necessary work and the need for timely execution of deliverables, the RDVRP is seeking the help of a reputable international consulting organisation to carry out the soil survey task. The organisation to be selected will work as a Contractor to the RDVRP and under its direct supervision with support from the Ministry of Agriculture Land Use Department (LUD). The RDVRP will also have responsibility for overall supervision and quality control of the Contractor's activities, as well as the execution of designated support activities.

This document herein presented constitutes the Terms of Reference (TOR) that define the scope, technical specifications, duration and other requirements for the technical consultancy to be undertaken by the Contractor.

The companies and organizations invited to tender for this task will be expected to adhere to the specifications as outlined below. The offers, however, may differ from the TOR specifications as outlined below, as long as such offers clearly show that the suggested differences are technically and /or economically more favourable to the evolvement of a thorough and comprehensive soil survey.

1.2 Objectives

The overall objective of the consultancy service is to make a comprehensive and usable soil survey for all of Grenada, Carriacou and Petit Martinique, except for built-up urban and industrial areas, after studying and evaluating the existing data and Information. The specific objectives of the survey are to:

a. Identify, locate and describe agricultural soils and other areas designated for infrastructural development throughout Grenada and dependent islands (small uninhabited islands are excluded).

b. Describe and map in detail about 31,160 ha identified as being most suited for agricultural and or infrastructural development.

c. Provide interpretations for the soils in Grenada for different uses, with particular emphasis on the suitability of map components for:

    - Agriculture
    - Engineering (road construction and other infrastructural development)
    - Land suitability

d. Provide a database that can be used for broad planning and management, related to other land-uses in Grenada, such as parks and recreation, urban development, public services, wildlife reserves, exploitation of natural resources, disaster risk mitigation, and

e. Establish a computer-based soil information system (SIS), consisting of a Database Management System (DBMS) and a Geographic Information System (GIS), to input and display geographic data, such as aerial photographs, images and maps, as well as non-geographic data.

1.3 Location of Project Area

Grenada is a tri-island State which includes the Islands of Carriacou and Petit Martinique and some smaller uninhabited Islands between. It is located at the southern end of the Windward Islands approximately 72 km south of St. Vincent. The total area of these three inhabited Islands is 348 sq. km, with Grenada (the main Island) being 312 sq. km; Carriacou 34 sq. km and Petit Martinique 2 sq. km.

The area to be surveyed for this TOR, consists of the entire tri- island state of Grenada, Carriacou and Petit Martinique, after excluding small uninhabited islands, urbanized and industrialized areas and locations with restricted or limited due to steepness.

1.4 Environmental Setting of Grenada

1.4.1 Climate

Grenada is impacted by a tropical climate which is characterized with annual average temperature of 26^{o}C, ranging from 23 ^{o}C to 32 ^{o}C. Cooler temperatures are usually experienced from November to February. Annual rainfall is categorized into a dry and a wet season. The dry season runs from January to May and the wet season from June to December. There is significant variation in rainfall distribution across the country. The mountainous areas can experience an average rainfall of about 3880 mm while low lying areas along the northern and eastern coastline.

1.4.2 Geology and topography

Grenada is among the Caribbean islands with the most rugged terrain. Gumbs (2001) characterised 90% of its land area as strongly sloping to very steeply sloping, with just over 23 % as steeply sloping land. Grenada is dominated by a north-south axial range of mountains with peaks ranging 680-840 m. The range is aligned westward, resulting in more gently sloping lands and extensive coastal flats on the east. To the south is a deeply indented coastline with evidence of submergence. The island is predominantly of volcanic origin, although some sedimentary rocks of the Tertiary and Quaternary periods are present. The island was largely built up by a series of volcanic eruptions during Tertiary and early Pleistocene times. This volcanic activity has given rise to lavas, ranging from alkaline to acid andesites, which are well fractured and jointed and extensively weathered pyroclastic rocks, which include volcanic ash, tuff, and agglomerate (Ternan et al. 1989). A distinct feature of Grenada's volcanicity is the occurrence, within restricted geographic range, magmas of contrasting geochemical characteristics (Arculus 1973).

1.4.3 Soils

The soils of Grenada are predominantly of volcanic origin. According to Vernon et al (1959) soil type differences on the island are influenced primarily by climate (principally rainfall patterns) and topography. Three broad soil groups were identified: “red earths” formed in the interior where rainfall is higher with greater chemical weathering, resulting in highly leached clays. Given the predominance of iron and aluminium oxides, soils in the high interior are reddish. They are fragile with low nutrient storage capacities, especially when their organic matter is depleted. In drier areas the montmorillinitic (2:1 clays) dark grey “shoal”, less-weathered ash soils of moderate to high base status, have developed. They are usually poorly to moderately drained. The other major group, termed the “brown earths” is described as an intermediate of the first two groups. They are well to excessively well-drained, mainly in drier areas.

Most soils in Grenada are classified as clay loams. In fact, clay loams account for 84.5% of soils, with clays 11.6% and sandy loams 2.9%, respectively. The three major types of clay loams are the Woburn, Capitol and Belmont clay loams. Together they occupy 77.8% of Grenada soils. There are minimal occurrences of limestone and tuffaceous shale and small areas of alluvial soils in strips along the lower courses of major rivers. Although the latter is minimal, traditionally they have played a major role in agricultural production.

The majority of soils developed in Carriacou and Petite Martinique are generally of low to moderate natural fertility, with low water retention and are highly erodible.

1.4.4 Land-use

Most lands in Grenada are privately owned. Sixty percent of the total land area is under agriculture. Tree crop production led by the nutmeg and cocoa occupies 13,670 ha or 70% of agricultural lands. Food crops, maize, peas, ground provisions (yam and sweet potatoes) are grown island-wide. Forest covers 4000 ha and 75% of this area is located in two blocks of forest reserves around the highest peaks, at the Grand Etang and Mount St Catherine

1.4.5 Existing Database

Several studies conducted on the soils of Grenada were completed mostly in the pre-independence era. These studies represent valuable sources of information on the surficial material, landform physiography, geology, engineering properties and soils of different areas in Grenada. This section provides a brief critical review for a selection of the more important studies completed to date.

1.4.6 Soil classification

The current soil classification is largely based on the work of (Hardy et al 1932) and (Earle, 1924). It was an attempt to define soil classes more accurately using a single

group of soil formation attributes and observable stages of soil development. The basic process used was weathering together with the weathering-leaching balance and the resultant development of clays. In effect, rainfall patterns and topography were considered the most important soil formation factors. Other factors including parent material, vegetation and time were discounted (Vernon et al 1959). It was anticipated that this would provide a suitable basis for fairly homogenous soil classes with respect to soil fertility problems. An improved understanding of soil and land suitability for agriculture and particularly cocoa production was the major focus of these early efforts.

The authors of the report Soil and Land Use Surveys No.9 Grenada, which is still the standard reference for soils information for the island had reservations about the geological data sets they had to rely on to develop the soil survey Grenada. They noted that none of the available data sets comprised "a true geological survey and certainly not as detailed and reliable as might be desired for the purposes of a soil survey" (Vernon et al 1959, p.5). Fortunately, several more detailed geological studies were completed since (Martin-Kaye 1969; Graham 1980; Arculus 1976; Hawkesworth et al. 1979; Bird et al. 1993; Arculus 1973).

1.4.7 Grenada Land Information System

The Grenada Land Information System (GLIS) was developed through a FAO technical cooperation programme (TCP/GRN/2201) to support land resources evaluation for agricultural development in Grenada. It was designed to establish a basis to rationalize and improve efficiency of land use planning. It comprises computerized and geographically referenced databases using a geographical information system (GIS) platform. It includes software for connectivity to an automated land evaluation system (ALES). The GLIS is a key resource for the LUD with the potential to assess the physical and economic suitability for rain-fed cropping and forestry (a total of 42 species combined). The land resources database within GLIS includes a soil layer among other themes like climate data, hydrology, elevation and land use.

The soil data within GLIS is based largely on (Vernon et al 1959) but included an attempt to reference the Grenada based soil classification to the WRB (1990) system. It is notable that this referencing was considered provisional since there was insufficient soil data for a full-scale, bona fide reclassification and precise referencing to the WRB soil classification system or the US Soil Taxonomy.

1.4.8 Soil map

The original soil maps were digitized and transformed into the GLIS coordinate system. The maps include a total of 35 soil types that were described to family, twenty-nine soil types were identified in Grenada and nine in Carriacou (some soil types were found in both islands). A total of seven miscellaneous land units were identified in the maps. They are areas with at least one major limiting factor that

renders them unsuitable for agriculture. These include: Mangrove swamps, Inland swamps, Salinas, Beaches, Saline areas (in places where a coastal beach or mangrove swamp may be backed up by almost bare sandy or clayey salinas just above sea level), River wash (occurs along main river courses, mainly in their lower reaches and usually consists of dumps of bouldery or cobbly gravels, depending on age overgrown with rough bush), Urban areas (heavily built up sections of cities, towns and villages), and Lakes.

The researchers reported inherent errors in the soil maps they reproduced. The errors were due to the transformation process and are in the order of 2 to 50 m along both x and y axes. These errors have most likely persisted in the datasets now available. These digitized maps are projected in UTM 20N, WGS 84.

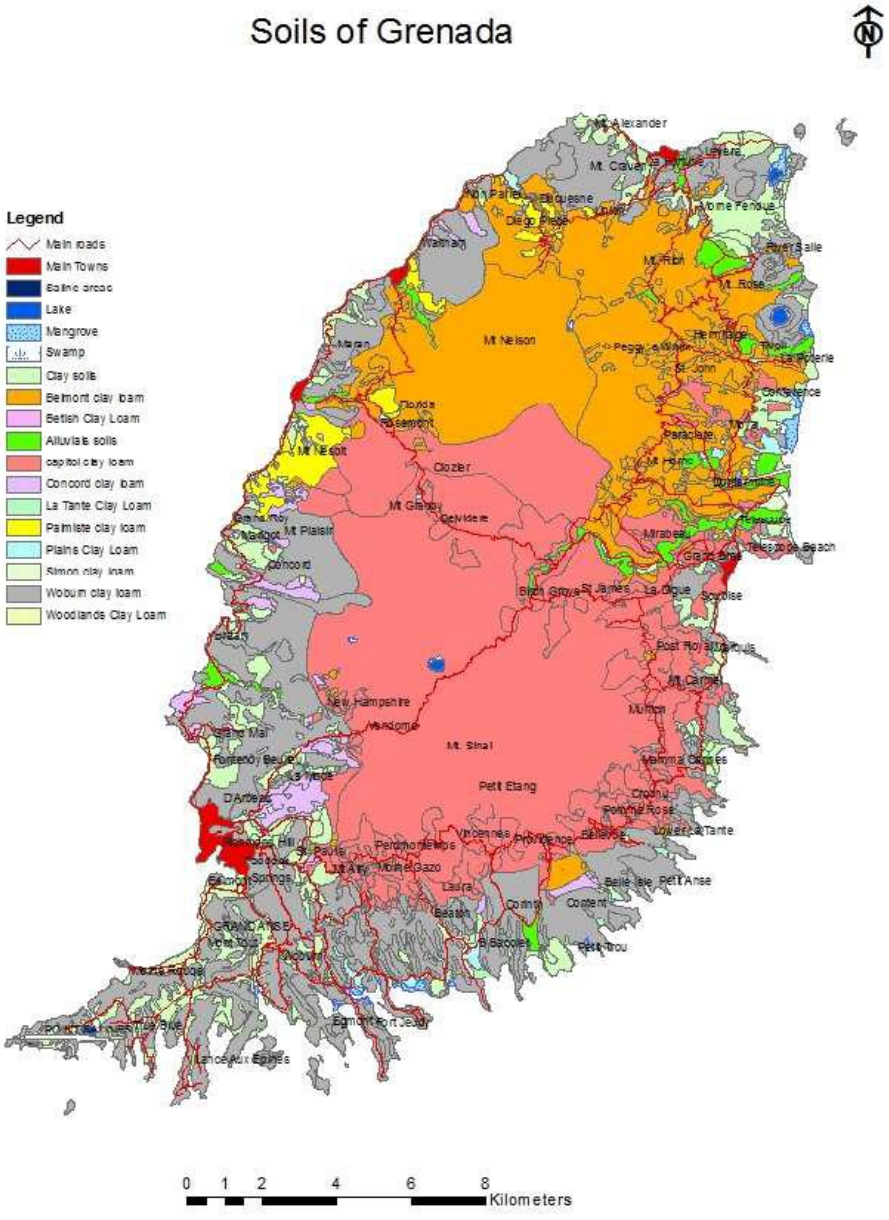

Figure 1 Map of Grenada Soils showing spatial distribution of soil types (LUD)

2 Scope of Work and Technical Specifications

The scope of work and technical specifications of the consultancy services required from the consultant are outlined below:

Survey and Classification

The technical activities of the survey would be carried out within two clearly defined strategies, namely:

2.1 Phase 1 - Pre-Field Work (Preparatory Phase)

Preliminary zoning:

Prior to the start of the organised survey and mapping all necessary background work required to identify and outline homogeneous regions into distinct zones must be completed. This includes but may not be limited to the following:

I. Collection, compilation and evaluation of all background data relevant to the conduct of the soil survey. Information concerning climate, geology, landform, vegetation, soil, agricultural practices, and land use will be taken from GIS platforms available within the Land Use Department of the Grenada Ministry of Agriculture and existing documents such as the Grenada Soil and Land Use Survey (Vernon, Spector and Jones, 1959), high resolution RBG aerial imagery, a LiDAR topographical dataset for the island, topographic maps, geological maps, previous soil surveys and related published reports and articles.

II. Interpretation of available LiDAR data, aerial photographs, analysis of satellite imagery and field findings to develop a high level schematic delineating zones to be sampled for agrological or engineering purposes and those to be excluded based on their morphology (for example very steep, rocky outcrops) or their current land use (for example forests, mangroves or swamp land). The exercise must include an analysis of geomorphological units supported by relatively few exploration sites, where necessary. The aim here is to provide a broad national scale demarcation of similar landscapes and soil types that will either be included in the detailed survey.

2.2 Phase II - Field recognition:

Zones identified for sampling in Phase I must be further examined primarily through field visits and further exploration to confirm soil types, their extents and physiographic relationships. This shall include but may not be limited to:

I. Exploratory field trips to examine the different landscapes, broad soil patterns and land use. Input from resourceful present and former staff of the Ministry of Agriculture is highly recommended for this exercise.
II. Preparation of a detailed soil sampling plan for each zone identified for sampling in Phase I.

2.3 Phase III - Soil Survey (detailed study)

Soil survey procedures used shall comply with the guidelines from USDA Soil Survey Manual (Soil Science Division Staff, 2017a). For the purpose of soil classification, two systems will be incorporated into the soils database. With respect to soil taxonomy, classifications will be in accordance with the FAO World Reference Base for Soil Resources, 2014 (IUSS Working Group WRB, 2014). For the classification of soils for engineering purposes, the Unified Soils Classification System, in accordance with ASTM D2488 and D2487 will be used.

2.3.1 Purpose and extent

This component will involve conducting a detailed soil survey, at a scale of 1:12,000 for the entire tri-island state of Grenada, Carriacou and Petit Martinique (except uninhabited smaller islands, urban or built up areas, industrial and miscellaneous areas like beaches, mangroves, water bodies, locations that are too steep). A survey at this scale is characterized as Order 2 by the United States, Natural Resource Conservation Service (NRCS) and as detailed (high intensity) according to the FAO. The purpose of this component is aimed at field exploration, sampling and laboratory tests. It is likely that categorizations made in Phases 1 and 2 may be changed depending on the findings (from detailed sampling and analyses).

Field Survey and Mapping

The detailed soil survey shall be carried out in accordance with the guidelines for mapping at the 2nd order level of detail, as specified in the Soil Survey Manual (Soil Science Division Staff, 2017a). The soil shall be mapped as single type units where possible. Because of the intricately complex topography, it may be necessary to map consociations (mixed but with one soil type dominant) or associations (mixed with several co-dominants). However, an accurate map will have well-delineated boundaries between soil types and a few miscellaneous areas. Existing soil maps and data, aerial photographs, Light detection and ranging (LiDAR)-derived elevation data, supplemented by interpretation of satellite imagery, will be used as the basis for conducting this survey and characterising defined map units. The limited number of observations possible must be supplemented by an understanding of the soil-vegetation-landscape relationship, sufficient to predict soil types in an area and determine the boundaries.

2.3.2 Density and total number of field observations

The density of sampling points will be driven by the target scale of the map (1:12,000), in order to reflect the desired map resolution. Initial delineation should be done on field sheets and later collated into the final soil map. The area to be surveyed is estimated at 31,806 ha. Generally, the sampling density is specified at 1 to 4 cm^2 of map area regardless of scale (Rossiter, 2008). At a scale of 1:12,000, 1 $cm^2_{(map)}$ = 120 $m_{(ground)}$ x 120 $m_{(ground)}$ = 14,400 m^2 = 1.44 ha. Hence, one observation per 1.44 to 5.76 hectares. At one observation for every 4 hectares just under 8000 observations would be required, if strictly applied throughout the target area. Rationalization of the density and total number of observations must be made based on preliminary zoning and field recognition outlined in Phases I and II, respectively. This is likely to significantly reduce the total area that must be surveyed and the total observations.

2.3.3 Location of observations

A conventional and convenient method for observing and sampling soils in mountainous landscapes with many volcanic cones and their remnants is by altitudinal transects. Transects are located on remote sensing imagery so that they cut across the topographic grain of the different land systems. In the example depicted for Grenada in Figure 2, transects are spaced at 0.5 km. For Carriacou and Petit Martinique a grid sampling strategy is proposed. It may be necessary to choose alternative sampling points where access or soil cover may preclude sampling at designated points. It may also be necessary to alter the sampling density based on zoning and field recognition results. The contractor shall develop methodologies for selection of alternative sampling points and sampling densities and consistently use them as necessary and indicate in field notes and reports when this is done, with appropriate justification.

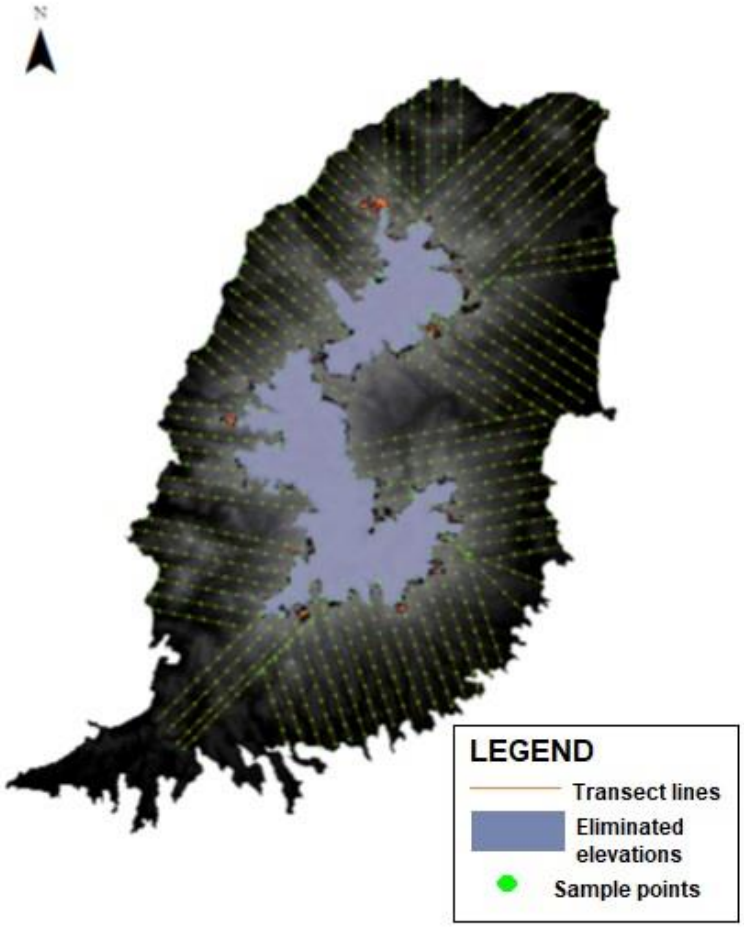

Figure 2 Transects and Soil Sampling Points

2.3.4 Types of Observations

The following minimum kinds of information shall be described at all observation sites in field notes: profile number, soil profile description status, date, author(s), location, elevation, map sheet number and grid reference, land form, position within the landscape, rock outcrops, surface fragments (stones), micro-topography, soil erosion, signs of surface litter, faunifacts, effective rooting depth, parent material, land use (including description of vegetation or crop cover), and evidence of human influence or disturbance. The topographic examination should particularly look for old scar faces, slump bulges, and other signs of previous mass movement.

The bulk of observations (75%) will be made by auger boings to depth of 1.2 m or to the top of the indurated layer, whichever is shallower. The boring must be deep

enough to observe one or more distinguishing feature about the soil to permit confident classification to the series level.

Auger observations shall be made at regular intervals along transects lines to confidently determine the composition of representative map units and the proportional extent of each taxon represented in each mapping unit. A minimum of 5 transects, each consisting of 5 or more points, will be made for each map unit. Transects will be uniformly distributed throughout the area of occurrence of each map unit.

For each taxon recognized and mapped, complete pedon descriptions will be made from a minimum of 10 purpose-dug profile pits or in existing free-face exposures, such as road cuttings. Where cuttings are used, the face needs to be cut back by at least 50 cm. The profile should be at least 1.5 m deep or 30 cm below the top of cemented or indurated layers or to bedrock, whichever is shallower. Based on present knowledge which hinges primarily on the work of Vernon et al (1959), it is believed that about 35 soil families exist across Grenada, Carriacou and Petit Martinique. A more detailed classification could reveal still a greater number of soil series. However, a conservative estimate of the minimum number of profile pits and free-face exposures could be 350 at 10 per series. The soil should be described by natural horizons for: matrix colour, mottles, hand texture, consistence, stoniness, soil structure, porosity, rooting and faunifacts.

Particular care is necessary to identify signs of buried soils (darker colours, crumb structures, dense rooting) as these could be due to local slope instability. Also, seepage zones that are wetter than above and below may be potential shear planes and indicate susceptibility to slope failure. Layers with unusually high density of rooting compared with above and are probably wetter and may be potential shear zones.

2.3.5 Laboratory Investigation

Representative samples of the soil horizons collected during the survey shall be subjected to complete physical and chemical analyses so as to thoroughly characterize the soils and to classify them according to the FAO World Reference Base. The number of samples to have complete analyses will depend on the number of soil reference groups or taxon identified. Samples from at least one representative pedon for each identified taxon will be analysed. It is anticipated that about 140 samples (on average, 4 horizons from each of the 35 pedons) will be subjected to complete analyses. In addition to these analyses, samples of selected horizons may have to be subjected to certain analysis in order to answer specific questions pertaining to classification or behaviour.

The laboratory analyses will be carried out according to analytical procedures prescribed by the Soil Survey Field and Laboratory Methods Manual (Soil Survey Staff, 2014). The contractor will rationalize based on existing facilities and capacities

which analyses can be done locally or must be sent to a certified external laboratory that meets the approval of the RDVRP.

Parameters to be determined in the laboratory shall include:

Physical Parameters:

- Particle size distribution
- Bulk density and porosity using undisturbed core samples
- Soil moisture at 1/10, 1/3, and 15 atmosphere tensions for each horizon of one representative soil profile of each soil series recognized.
- Soil surface fragments larger than 75 mm
- Liquid limit
- Plasticity index
- Colours, mottles and consistence should be done for wetted soils as well as in the field moisture state.
- Unified Soil Classification System (USCS) engineering classification

Chemical Parameters:

- pH in water saturated soil extract;
- Organic carbon and organic matter content;
- Total N;
- C/N ratio
- Available phosphorus (Troug/ Mehlich 3);
- Exchangeable cations by pH buffered 1M ammonium acetate leaching (includes potassium, calcium, magnesium, manganese, sodium);
- Cation exchange capacity (CEC) by NaCl leaching and NH_4 distillation;
- Extractable Al by leaching with 1M KCL;
- Crystalline and labile free oxides of iron and aluminium extracted by oxalate and diothionite extractions;
- Total nutrients extracted by N Carolina tri-mineral acid mixture;
- Andic properties and particularly allophane content should be determined by the pH_{NaF} test (Fieldes and Perrott, 1966).
- Clay mineral identification in samples from three different depths of each representative profile of the most extensive soil identified.

2.3.6 Soil classification

At the scale of mapping essentially a soil series map will be produced. For classification of a soil (according to the WRB classification system) at the second level, the reference soil group (RSG), principal qualifiers and additional qualifiers

must be included as this is the most comprehensive level of detail for soil description in the WRB (IUSS Working Group WRB, 2014).

2.3.7 Land Assessment

The soil, regolith and topographic attributes should be combined to delineate zones with designated susceptibility to mass movement. The areas with high and medium risk should be designated as special conservation areas, development within them should be banned or permitted only with very stringent protection measures and should include guidelines for management of subsoil regolith water flow. Areas with low or zero mass movement risks can be assigned to general agriculture and other land uses with appropriate national environmental safeguards. These areas should be assessed separately for their suitability for the main crops, using the Land Suitability Framework (FAO, 1976). Initial delineation should be done during the survey on field sheets (or digital formats where utilized) and later collated into final soil maps. With reference to the FAO land suitability framework, the inherent local conditions specifically relating to cultivation on slopes and other issues related to land use may require practical and technically justified diversions to suit local conditions.

2.3.8 Data Interpretation and Presentation

After final delineation of the map units, a thorough description of each unit shall be presented in either narrative or semi-tabular format. Guidance on preparation and presentation of soil survey interpretations is given in Part 617 of the National Soil Survey Handbook (Soil Survey Staff 2016). The map unit description should include the following minimum kind of information: map unit name, slope range, setting on the landscape, climatic setting, percent composition of named components and included soils not part of the map unit name (soil series or taxa above soil series), popularized description of each soil given in the map unit name, erosion and landslide hazard, ground cover description (including commonly cultivated crops) and a brief listing of management concerns and needs.

2.4 Data Management

To ensure effective and optimum utilization of the large database that will be generated from the soil survey, a computer-based soil information system (SIS) shall be developed to provide an efficient and useful environment for handling and managing the soil related data. The SIS will comprise a database management system (DBMS) interactive with GIS. The SIS shall be developed and operationalized to:

- Input, analyse, manage and display various kinds of geographic and non-geographic information,
- Relate information about soil properties and identify, using statistical methods and indicators, current and possibly future problem areas.

- Support the evaluation of soil classes with respect to land suitability for agriculture ((FAO, 1976) and engineering soil uses erosion hazard, landslide risks, irrigation, drainage, and other criteria,
- Produce information related to individual survey mapping units and produce interpretative maps at different scales,
- Provide support to produce and display general maps of Grenada, Carriacou and Petite Martinique in graphical and imagery formats showing the various distribution of soil classes at different scales,
- Provide interactive displays and reports about soil class characteristics and other associated information to be used for soil management and planning, and
- Delineate, display and identify areas of potentially agricultural soils and soils best suited for infrastructural development, at different scales.

All of the field, laboratory and graphic data, and other related information, acquired during the survey shall be synthesized and analysed. Several interpretations of the mapped phases of each soil series in the survey area shall be generated to show the potentiality and limitation for agriculture as well as engineering uses. Rating criteria and suitability classes for agriculture and engineering will be guided by Chapter 8 of the USDA Soil Survey Manual (Soil Science Division Staff, 2017b). Other suitable methodologies may be recommended and used by the contractor. Modifications to available interpretation models may be necessary to ensure compatibility and usefulness for local conditions. These are acceptable providing there are plausible explanations and justification.

2.5 Training

2.5.1 Introduction

Preliminary evaluation of available resources with the LUD of the Ministry of Agriculture highlighted several capacity issues requiring inter alia improvements in the collection, organization, analysis, interpretation of soil data and information and the generation of requisite reports for varied uses. A greater understanding among respective stakeholders of the survey process and its implications for planning and overall development was also highlighted as a priority.

2.5.2 Training Needs Assessment and Recommendations for Training Options

The Contractor shall:

Determine the skills required to meet the outputs necessary for operationalising and maintaining a Soil Information Service for Grenada;

Assess what training is required to develop those skills;

Provide a series of options for delivering the trainings;

Develop a framework that will allow the LUD to assess their existing skills against its needs and present options for meeting any skills gap.

2.5.3 Training Workshop

Using a training workshop format, the Contractor shall provide requisite training to relevant stakeholders:

This will include:

Presentations on soil survey findings and related interpretations of the results. The implications for agricultural development and engineering, in Grenada must be specifically addressed.

A full hands-on experience of the various systems and tools developed as part of the Grenada SIS. The extent of their functionality usefulness for positively impacting the planning processes and national development must be thoroughly explored.

Training manual

A training or user's reference manual on the Grenada SIS shall be prepared giving the requisite detailed instructions on how the system should operate, to include options for troubleshooting problems that may arise.

2.6 Reporting requirements

The reporting system of the survey work to be undertaken by the Contractor shall include the following:

2.6.1 Inception Report

The Contractor shall prepare and submit an inception report within a maximum of thirty (30) calendar days after signing the contract. In the report, the Contractor shall:

Report on the pre-field work activities outlined above

Describe initial findings and provide any comments on the TOR.

Present a detailed work programme and methodology for completion of the field survey.

Present a programme for the use of resources including but not limited to personnel, equipment and materials.

Provide a proposed outline for the final soil survey report.

The RDVRP through the TWG will provide comments, in writing, to the Contractor within three (3) weeks from receipt of the report. The Contractor shall then make the necessary modifications agreed by both parties.

2.6.2 Progress reports

The contractor shall report (monthly) on the progress of all aspects of on-going project activities to the project consultant and copied to the Portfolio Manager of the RDVRP. These reports should be short and concise and must be submitted within one (1) week of the following month from which they are due. The report shall also include a program of work for the following two (2) months.

2.6.3 Interim Reports

Interim reports are required at the completion of each major task and according to the work schedule prepared and agreed to during the inception phase.

The following interim reports shall be prepared:

- Phase I and II: Pre-field work activities (including proposed zoning plan)
- Phase III: Field survey
- Laboratory Investigations
- Land assessments
- Data Management
- Training needs assessment
- Training workshop

The RDVRP through the TWG will provide comments within three (3) weeks from receipt of reports. The contents of these reports will be incorporated, as appropriate, in the final survey report.

2.6.4 Draft Final Report and Soil Map

A draft soil survey report including all the necessary maps, texts and illustrations shall be submitted to the Portfolio Manager of the RDVRP three (3) months after conclusion of the field survey. The RDVRP will provide, within six (6) weeks from receipt of the report, written comments to the Contractor for consideration in preparing the final version. The Contractor shall discuss the draft report with the TWG and the Consultant prior to its final production.

The report shall include, but not necessarily limited to, the following:

- An introductory section explaining the purpose of the survey, starting and finishing dates, survey methodology and background information.

- A general description of the study area including geographic location, size of survey area, physiography, geology, geomorphology, native vegetation, climate, natural drainage, wildlife, present land use, water resources, settlement and communications,
- Descriptions of the individual soil taxonomic and map units (shown on the maps) supplemented with tables showing their characteristics, relationships and the associated landform, parent material, vegetation and land use features
- Predictions of the yields of the common crops of the areas under different sets of management practices for agriculture (particularly crop production),
- Interpretations of soil phases for several uses, including suitability for agriculture and non-agriculture (engineering) uses with reference to standards and specification for a 2nd order soil survey.
- Discussion of the soil formation process, genesis and controlling factors of the different soil types in Grenada.
- Certification statement
- Signature of approval from soil surveyor/soil scientist

- A set of maps including:
    - Detailed soil maps of Grenada, Carriacou and Petite Martinique at the scale of 1:12,000
    - Land use maps for the Tri-island state of Grenada (at 1:12,000)
    - A set of interpretative maps at 1:12,000 scale, showing the suitability classes for agricultural uses (according to FAO soil capability with requisite modifications for local conditions) (FAO, 1976) and for engineering uses according to the Unified Soil Classification System (Howard, 1986; USDA 1990; ASTM 2006) and

- Outline of proposals for applied research projects on soil related problems that require further investigation.

2.6.5 Final Report and Map Production

After approval of the draft soil survey report by the TWG, the contractor shall present the RDVRP Portfolio Manager with four hard and two (2) electronic copies of the finalized report and maps by the end of the 12th month of the consultancy service. The final report shall include compiled and edited soil map atlas sheets

The page size of the report may be adjusted depending on the final size of the soil survey maps, and whether they are folded or inserted into pockets. Printing of text

and tables are to be in black ink, and are to be uniform throughout each page and between each page.

The cartographic guidelines for soil map compilation, soil map finishing, and soil map digitizing outlined in the USDA-NRCS National Soil Survey Handbook, Part 647 - Soil Map Development, should be followed (Soil Survey Staff 2016). The basic procedures and principles outlined therein to ensure quality control and assurance of the mapping process shall be adopted. High accuracy standards are required because of the need to accurately locate relatively small areas of soil, and because the soils map features will be digitized for use with other geographically controlled maps in GIS.

The other following points shall be observed in the production of the photo- or image-based soil maps:

- All map unit boundaries shall be closed,
- Each map unit shall have the correct map symbol
- The boundaries and symbols on each map shall be consistent and join those on adjacent maps,
- Each map shall show sufficient features (roads, cities, villages, coordinates and other prominent sites, etc.) to facilitate the location of map units on the ground, and
- The printed maps shall match each other in tone and density of colour.

2.6.6 Other documentation

- In addition to the reports and maps mentioned above the Contractor shall also provide the RDVRP with the following:
- All field notes, including all pedon descriptions, transect notes and original field map photos and topographic sheets (these items are to be arranged and filed by an orderly and readily retrievable manner; detailed pedon descriptions to be filed by soil series, informal notes about pedons and map units to be filed by soil series, informal notes about pedons and map units to be filed by map unit, and field soil survey photos and sheets are to be arranged in sequence with an appropriate and legible photo and map index).

- All original laboratory test sheets and forms filed by soil series

3 Management and Coordination

3.1 Responsible Body

The project will be managed Regional Disaster Vulnerability Reduction Project (RDVRP) and directly supervised by its Portfolio Manager.

3.2 Management Structure

The contract will be between the Contractor and the Ministry of Finance of the Government of Grenada. However, management and supervision responsibilities will rest with the RDVRP through the services of a designated consultant. The consultant will have responsibility for supervising and coordinating all project activities for and on the behalf of the RDVRP. Close coordination between RDVRP's Consultant and the Contractor's team shall be necessary to ensure successful implementation of the requested tasks. In addition to regular informal communication and regular reporting, progress review meetings will be organized on a monthly basis between the consultant and contractor team(s) to enhance coordination and smooth implementation.

The contractor shall consult and work closely with the consultant and the TWG of the Ministry of Agriculture and Lands during the life of the project. The Contractor is also expected to consult with other stakeholders (from governmental and non-governmental institutions/agencies), as required.

3.3 Client's Role and Responsibility

The LUD of the Ministry of Agriculture is expected to provide logistical support to the contractor and facilitate project activities as much as is feasible.

The client shall provide the following:

- Suitable Office space, with desk and chair for the team leader during the survey. All available and relevant maps, updated high resolution DEM and satellite and aerial imagery to support the conduct of the soil survey and related activities.

- Available reports and documentation concerning soil, geology, geomorphology, climate, crops, vegetation, wildlife, land use and other related issues.

- Access to the LUD hardware and GIS-based files that can facilitate planning and execution of related project tasks.

- Facilitate access to private lands for conduct of the soil survey.

3.4 Contractor's Role and Responsibility

The Contractor shall:

- Execute the technical program outlined in Section 2 of the TOR, including all required soil sample preparation and arrangements for the required analyses.
- Ensure that the quality of data, results, reports and maps produced throughout the service, are to the satisfaction of the RDVRP and meet the applicable technical and quality specifications and standards.
- Provide all the remote sensing work required. This includes interpretation of aerial photographs and image processing of satellite data
- Manage all administrative and logistic aspects of the Contractor's team. This includes , but will not be limited to the following:
    - Recruitment and immediate supervision of staff (Note: causal field labour must be sourced locally), relocation and travel arrangements for staff and their families.
    - Provision of personal and field transportation.
    - Providing accommodation, health care, insurance and schooling, as required.
- Ensure that only persons with the requisite competence, skills and qualifications are engaged.
- Ensure that suitable office arrangements are made for
- Develop and implement a robust quality assurance and control system that is consistently applied through all aspects of the survey.
- Ensure that any deviations from the TOR is first discussed with and agreed by the Client
- Acquire field equipment required for conducting the work (e.g. augers, shovels, compasses, pH meters, GPS units, Munsell colour charts, stereoscopes etc.). Upon completing the consultancy service, these equipment items will become the property of the RDVRP.
- Acquire and install all hardware and software components required for developing the SIS.

3.5 Implementation schedule

The total duration of the consultancy service shall be 12 months. A tentative breakdown of the implementation schedule for the main activities is given in Table 1 below. Duration of these activities can be modified by the tenderer provided that the start and finish of the whole consultancy service are within the 12-month duration

Table 1: Implementation schedule of the soil survey activities

Activities	Time (Months)											
	1	2	3	4	5	6	7	8	9	10	11	12
1. Pre-field work												
2. Field survey												
3. Data management												
4. Training												
5. Reporting												
(i) Inception report												
(ii) Progress report												
(iii) Interim report												
(iv) Draft final report												
(v) Final report and Map Production												

3.6 Labour Scheduling and Cost

In estimating person-month requirements and cost of the services the contractor should ensure that the proposal fully account for all fees and direct expenses required for fulfilling the above requirements and the following items:

- Contractor's remuneration
- Contractor's out of pocket expenses
- Analytical services
- Shipping and handling cost
- Communication cost
- Documentation and production cost
- Transportation
- Supervision cost

3.7 Ownership

All field notes, reports and data such as maps, diagrams, drawings, specifications, statistics computations, databases format and data, and any other supporting records or materials acquired, compiled or prepared by the contractor in the performance of the contract as well as any outcome of the implementation of the contract, shall be the absolute property of the Contracting Authority unless otherwise specified.

3.8 Comments by the Contractor

The Contractor may make comments and suggestions for improvements to the TOR. The financial implication, if any, of these recommendations should be indicated separately in the financial proposal. These however must be agreed by the owner before implementation.

4 Qualification requirements

To qualify for a possible award of contract, the bidder's package must meet the technical specifications of the requested work program and satisfy the following qualification requirements:

4.1 Company's experience

A thorough description of two or more contracts of soil survey projects that must be completed, or is in progress, for any government or private industry shall be documented. Also, samples or excerpts of such works shall be submitted with the bid

package. The contact details (including name, email, address and telephone number) of technical representatives and contracting officers for such projects should be included.

4.2 Company's capability and experience

A statement and documentation shall also be included on the firm's capabilities and facilities in supporting and related fields such as:

- Soil taxonomy
- Remote sensing and image processing
- GIS and DBMS capabilities
- Training
- Laboratory analyses
- Land use planning and resource assessment
- Management and organization of large-scale field operation

4.3 Staffing

The bid package shall identify and thoroughly document the professional qualifications of all key members of the Contractor's team, which will be provided for execution of the consultancy service. A separate curriculum vitae should be submitted for each key staff member, to include educational background, work experience and publications.

The tenderer's task team will comprise:

- **Team leader, Quality Assurance Specialist and Mapping Crew Leader:** Each shall have a minimum of a Master's Degree in soil-related science with a minimum of 15 years of soil mapping experience, much of which preferably has been with soils tropical regions. Experience with soils in the Caribbean, especially with andisols, would be a considerable advantage. Furthermore, they should be thoroughly familiar with US Soil Taxonomy and WRB (FAO) soil classification systems.

- **Mapping Crew Members:** Each crew member must have the minimum of a Bachelor's degree in soil-related science, from an accredited college or university. Each one must also be thoroughly familiar with soil taxonomy, and must have a minimum of three (3) years of soil mapping experience.

- **Remote Sensing Specialist.**

  Degree in Geography, Physics, Earth Science, Mathematics with a diploma or concentration in Remote Sensing or equivalent. In lieu of a degree, an appropriate combination of education and experience may be considered. At

least 5 years of professional experience in a remote sensing role where tasks included; interpretation of aerial orthoimagery and LiDAR derived Digital Surface/Terrain Models. Experience with the classification of LAS format point clouds is an asset. Demonstrated experience with professional remote sensing software packages, such as ERDAS Imagine or equivalent is desired. Demonstrated experience in the use of remotely sensed data in geomorphological mapping and/or soils classification is desired.

- **GIS/Database Development Specialist**

  Degree in Geography, Physics, Earth Science, Mathematics with a diploma or concentration in Geographic Information Systems or equivalent. In lieu of a degree, an appropriate combination of education and experience may be considered. At least 5 years of professional experience in a GIS role where tasks included; creation or maintenance of geodatabases (preferably using a SQL DBMS), creation of task automation scripts and definition of topological rules for vector datasets, creation of high-quality cartographic products. Demonstrated experience with cartographic products for soils mapping is an asset. Demonstrated experience with professional GIS software packages, such as ArcGIS Desktop (10 or later) or equivalent is desired. Demonstrated experience in the creation/maintenance of soil information systems is desired.

- **Other short-term consultants, as required.**

- **Supporting staff** (to be locally sourced)

5 Reporting and communication

The team leader, quality assurance specialist or mapping crew leader should be available for consultation with RDVRP consultant at all times that work is being performed. Each of these staff should have an excellent command of written and spoken English. All reports, field notes and map descriptions must be prepared in English.

6 References

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