VOLUME II

Farming Systems Approach and Methodologies

CHAPTER 6

FARMING SYSTEMS APPROACH TO SOIL CONSERVATION

6.1 Farming systems: Requirements for successful adoption and implementation

A farming system can be defined as a reasonably stable arrangement of farming enterprises that are managed according to well defined practices in response to the physical, biological and socio-economic environments and in accordance with defined goals, preferences and resources. The integration of soil conservation into the farming systems therefore means that soil conservation methods must be sustainable in the physical, biological and socio-economic environments.

Clearly visible techniques like terraces and contour drains have become synonymous with soil conservation but there are many agronomic practices which are not generally associated with soil conservation but which reduce soil erosion or can be used to enhance soil conservation. The farmer, however has to take a conscious, deliberate and organized approach to ensure that soil conservation is one of the objectives of the farming system. With this approach, the farmer may not be required to make radical changes to his practices or significantly increase his inputs but may benefit from increased production.

6.1.1 Farming systems research and extension

Appropriate farming systems can be developed or improved and successfully adopted by farmers through the Farming Systems Research and Extension (FSR/E) methodology. FSR/E is an applied farmer oriented, agro-biological approach to research informed by socio-economic considerations in a team effort that includes extension responsibilities. It is an approach to generating, evaluating and delivering technology which is appropriate to the social and economic environment. If the technology is not to be rejected, changes must not be drastic and the profitability of the farm, which is a business, must not be decreased by the new technology.

To minimize the chance of rejection, the farmer must participate from the planning through to the implementation, evaluation and recommendation stages. The FSR/E approach can be used to select or develop the most appropriate soil conservation techniques to fit into the farming system with or without modifying the farming systems and to get farmers to adopt the systems. The emphasis here is on adoption and continuity.

Four stages are required for the FSR/E methodology and for the successful integration of soil conservation into farming systems. These are:

Diagnostic
Planning and Design
Implementation
Evaluation and Recommendation

Diagnostic Stage

Existing farming systems, soil conservation practices and the biological, physical and socio-economic environment are characterized and analysed. The information is obtained in two steps. The first is the review of existing literature of all pertinent information. The second is to carry out surveys which can be through formal, informal, quantitative or qualitative data collection procedures. Formalized and quantitative surveys for data collection can take time and be costly. However, recent trends are towards informal methods with complementary and focused formal surveys to verify informal results or to explore some particular aspect in greater detail. A popular method of collecting information quickly and cheaply is the *Sondeo* method which was originally formulated at the Institute of Agricultural Science and Technology (ICTA) in Guatemala by Hidlebrand 1981 (cited by Dolly and Young 1991). In this process information on the major constraints and problems limiting the productivity of a defined agricultural system is obtained and analysed. A rapid reconnaissance survey or appraisal of the farming system is conducted among representative farmers in a specific area within the system to obtain the relevant information. The information obtained by this method is later verified and strengthened by conducting a Baseline Survey which is a more formalized method of data collection. Diagnosis does not take place only at the beginning of the programme but is a continuous process and the information can be used to make modifications. An important element of this stage is consultation and involvement of farmers who need to be an integral part of the process.

Planning and Design Stage

In this stage, the information gathered during the diagnostic stage is analysed and farmers are actively involved in design. Problems are identified and prioritized and appropriate farming and soil conservation systems designed or soil conservation systems adapted to fit into the existing or modified farming systems. The appropriate expertise required to design and implement the systems must be put in place or consulted as necessary. The plan must be developed and finalised in consultation with the farmers. Provision must be made to monitor or to test the systems to be implemented.

Implementation Stage

All inputs required for the programme must be identified and made available on a timely basis, in accordance with the implementation plan. Staff must be fully aware of all aspects of their job and fully trained. If the programme involves testing or formulating of technologies, experiments are established in farmers' fields under farmers' conditions which are appropriate and therefore adaptable by farmers. The design of these experiments should be simple so that farmers will be able to understand and manage them with less supervision during the verification and evaluation stages. In this stage, the normal farmers' practice must also be carried out as a control for comparison.

Evaluation and Recommendation Stage

In this stage, the results of the on-farm experiments or testing are assessed. The researchers and extensionists must discuss the results with farmers to obtain their opinion of the treatments. The results must also be subjected to both an agronomic evaluation and statistical analysis. This assessment of the results from the farmers point of view is most important and must be clear before decisions on the treatments to be recommended to farmers or to be tested further. If one or two treatments show greatest promise they can be further tested in farmer-managed trials referred to as *validation stage*. This gives the farmers themselves the opportunity to manage and evaluate the treatments.

After evaluation or validation, treatments can be recommended for dissemination by extensionists through suitable communication systems. The dissemination process only starts when farmers begin to accept or adopt the technologies and when they begin to pay the cost of inputs and accept the risks of the intervention.

6.2 Baseline surveys and farm planning

In planning any enterprise, including farm planning, it is absolutely necessary to have the required data. In farm planning, data will be required to evaluate the capability and suitability of land for the current and proposed use under the given set of physical, social and economic conditions. The relevant data can be obtained by baseline surveys. These surveys provide the physical, social and economic data for developing the farm plans and the associated soil conservation methods appropriate to farming system and the physical and social environment.

The database which would provide the information for planning would include the following:

6.2.1 *Physical data*

Geographic location and elevation. This is needed to be able to locate the land on a map and to assess the implications of the proposed activities to the surrounding areas.

6.2.2 *Climatic conditions*

The important climatic factors are temperature, rainfall, relative humidity and wind. In the Caribbean, rainfall and wind are frequently the more important factors. These four-climatic parameters would determine the crops that are most suitable for specific locations.

Temperature: Some crops perform better under cool conditions e.g. solanum potato in the Christiana area of Jamaica; while others perform poorly under the cool and humid conditions of the high elevations eg. banana, mango, papaya in the elevated Montreal area of St. Vincent.

Rainfall: Data on the amount, intensity and duration of rainfall are very useful for the development planning of the farm. It determines, whether annual crops can be grown without irrigation in the dry season and the need for soil conservation on sloping soils.

Relative Humidity: The quality of some crops (e.g. Blue Mountain coffee) is improved but the incidence of pests and diseases is increased by high humidity.

Wind: Wind causes damage to crops and animals during storms and hurricanes. The banana crop is particularly sensitive. In addition high winds increase evapotranspiration and irrigation requirement. The information would help in identifying the most appropriate location for crops and in determining the need for windbreaks.

Evapotranspiration: This factor when compared with rainfall distribution would indicate whether irrigation would be required and would provide an estimate of the timing and amounts of irrigation.

6.2.3 *Soils*

Soil type: The classification, texture, fertility status and other soil properties, and area of the soil types are important. They help us to infer the behaviour, capability and appropriate land use of the soils. They play a vital role in the design of suitable farming systems.

Topography and Slopes: The physiography or land form in the project area help in the design of the farm plans, the location of crops, the infrastructural needs and soil conservation methods. The land forms may include alluvial plains (flat areas), terraces at different elevations, undulating, rolling and steep areas and each may have different soil types. The classification of slopes qualitatively by terms such as flat, gentle slopes, moderately steep, steep and very steep, or quantitatively into per cent or degree of slopes, aid planning.

Erosion Hazard: A map showing eroded areas, the degree of erosion which has occurred and the potential erosion hazard helps to determine the soil conservation measures which will have to be instituted to reduce the risk of erosion and to enable sustainable use to be made of the land.

Hydrology and Drainage: The amount and location of surface and subsurface sources of water, the present use and availability for irrigation are useful data. The availability and distribution of pipe-bourne water are also important.

Drainage of the soil is affected principally by slope, texture and structure. Low lying areas with poor or imperfect external or internal drainage, can become flooded or waterlogged for prolonged periods. These areas should be known and included in the data collected so that proper drainage can be effected.

Present Land Use: The present land use provides the necessary background for future planning. It also gives an indication of the capability of the land, although in some cases farmers may be persisting in activities that are degrading the environment. Natural vegetation is particularly useful in indicating the fertility status of the soil and specific soil factors as pH, salinity and excess or deficiency of ion species.

6.2.4 *Infrastructure*

The accessibility to the farm and to market and social amenities are essential for efficient and successful farming and must be assessed or included in the development plans.

6.2.5 *Socio-economic data*

Social infrastructure: These include schools, hospital or clinic, post office, churches, community centres, and determine whether the farmer will live on farm or elsewhere.

Factories: The presence or absence or processing facilities will determine the corps to be grown and therefore the land use in relation to the capability of the land.

Labour Availability: It is very important to know if an adequate supply of quality labour is easily available. This would influence the systems that can be introduced in light of the competition for the available labour.

Capital Availability: The availability of funds from lending agencies (such as banks) at attractive interest rates frequently determine the success of agricultural enterprises or lift the level of farming above subsistence. This factor is as important, in modern farming, as land, labour and management. Information on capital availability and conditions of lending influence the choice of systems to be implemented.

Preference of Farmers: Farmers often show preference for certain commodities or activities even though they may not be the most economical or appropriate for the environment. They usually have good reasons for their choices and these must be determined and considered in preparing the farm plan.

Markets: Markets must be available for farmers to sell their produce if the venture is to succeed. Knowledge of market demand or studies to provide the information, and marketing arrangements are all essential to the planning process and the success of the farming enterprise.

Technical Services and Farm Supplies: Advice through the Extension Service should be easily available to the farmers particularly to those small farmers who lack technology know-how or the resources to purchase the services. Other technical support services e.g. equipment repair and tractor rental are also important. Farm supplies needed for running the business successfully must be available in adequate quantities for the community of farmers or steps must be taken to expand the supply.

After all the data are collected, they should be carefully analysed and evaluated so that the appropriate land use and farming systems suitable for the physical and socio-economic environment can be selected. Computer programmes have been developed which would allow soil properties to be matched against crop requirements to give suitability ratings. Jamaica has developed the Jamaica Physical Land Evaluation System (JAMPLES) computer programme for rating the suitability of soils for specific crops. However, to develop farming systems which include soil-conservation measures for a particular project areas, all the physical and socio-economic factors must be integrated and this requires a team of people with the appropriate expertise.

6.3 Land Capability and Land Use

6.3.1 *Land Capability*

The demand for land for the various uses (residential, industrial, commercial, recreational, agricultural and nature reserves) continues to rise and to put pressure on a finite resource. It is therefore essential to make the optimum use of the resource without causing it to deteriorate. Proper land use planning is critical. Soil and land use surveys provide the information which allows planners and decision makers to know the potential or capability of the land. The surveys involve an inventory of the soils and vegetative cover of the land. Soils are classified according to defined criteria and this classification is used to assist in the determination of land capability or suitability.

Different soil classification systems for agriculture have been developed and many are specific for some countries. Two international systems are now used widely or universally, the 1974 FAO/UNESCO soil map of the world, and the 1975 United States Department of Agriculture (USDA) "Soil Taxonomy". The latter is the twelveth "Approximation on Soil Classification" developed by the USDA over a number of years. In addition there are many national classification systems in use.

The current agricultural land capability system in the Caribbean is based mainly on degree of slope as the dominant factor and to a lesser extent on factors of erosion, drainage, rainfall and soil fertility. This system of land capability classification is based on the former system of the USDA in which the suitability of the land for mechanised agriculture is of prime importance. This system was adopted by the Regional Research Centre (RRC) of the Imperial College of Tropical Agriculture (later UWI) and the classification of soils for each territory was published in a series of Soil and Land Use Surveys between 1958 and 1974. The relevance of this system to the Caribbean is questionable because (a) complete mechanisation is not possible due to size of farm, topography and sometimes crop type; (b) manual cultivation is often the only practical and suitable form of land management on most of the hillsides. This historical system is still referred to in many reports and is therefore briefly outlined below. However, if farmers only cultivated slopes as recommended, production would be reduced considerably. Therefore a more pragmatic, treatment-oriented approach is recommended which links slope classes to the conservation treatments required to avoid erosion.

In the RRC system soils are classified into seven land use slope classes shown in **Table 6.3.1**. Based on these slope classes, the risk of soil erosion and difficulties of management, the soils have been classified into seven land capability classes which indicate the most intensive suitable use as shown in **Table 6.3.2**. In some cases an eighth class is added for the extremely steep land, beach sand and mangrove, characteristics which preclude their agricultural use.

A broad grouping of the land in this manner into seven land capability classes is useful for some purposes such as determining a country's available arable acreage. It is not, however, adequate for specific land management recommendations. Between the extreme generalisation into seven broad land classes and the extreme detail of the soil survey, certain intermedial groupings are necessary in order to compile land capability classification.

Slope class is in many cases the primary factor in determining land capability, but the need to align this assessment with the detailed soil survey requires further subdivision within each land capability class. Four principal limiting factors are considered significant in this respect and they are shown by a small letter following the land capability numeral: "e" if the principal limiting factor is slope and erosion risk; "w" if it is excess water in the soil, seasonally or otherwise, giving poor natural drainage; "s" if it is a soil factor implying usually shallow or droughty soil; and "c" for the climatic factors.

TABLE 6.3.1 Slope classes and gradients

Slope class	**Gradients**	
	Degree	Percent
A	0-20	0-3
B	2-5	3-9
C	5-10	9-18
D	10-20	18-36
E	20-30	36-58
F	Over 30	Over 58

Source: Soil and Land Use Surveys carried out by the Imperial College of Tropical Agriculture (1958-1974)

TABLE 6.3.2 Land Capabilities Class, Slope Limits and Recommended Land Use

Land capability class and slope limits	Most intensive suitable use
I Slope limits 0-5° A and B slopes of good soils	Suitable for cultivation with almost no limitations.
II Mainly C slopes of good soils, and level land of less favourable soils	Suitable for cultivation with moderate limitations.
III Mainly D slopes of good soils, and gentler slopes of less favourable soils	Suitable for cultivation with severe or strong limitations
IV Mainly E slopes, some D slopes	Marginal for cultivation due to erosion risk but suitable for tree crops, pasture and forest.
V Mainly E and F slopes	Unsuitable for cultivation, but suitable for planted forest, tree crops and pastures.
VI No slope limit but shallow soil over hard rock (includes all steep rock land)	Unsuitable for cultivation due to erosion risk but suitable for tree crops, pasture and forest.
VII Mainly F slopes of deeper soils; No slope limit of soils with rock outcrop; river wash.	Unsuitable for agriculture should be left in natural vegetation.

Source: Soil and Land Use Surveys carried out by the Imperial College of Tropical Agriculture (1958-1974)

6.3.2 *Land Suitability*

This term is now used more often and refers to the suitability of the land for specific use and provides more details than Land Capability, particularly in qualitative economic terms. The details of this system are provided in the FAO Framework For Land Evaluation (FAO 1976). The term land evaluation is sometimes loosely used but the FAO Framework For Land Evaluation is quite specific. It provides a standard set of principles and concepts on which evaluation systems can be constructed. It emphasizes the importance of explicitly stating the intended land use, the level of management and whether it is based on current or potential suitability of the land.

6.3.3 *Land use and soil erosion*

A first defence against soil erosion is to use the land within its capability and to use the soil conservation practices that are appropriate for the capability class. The returns to inputs, including soil conservation, decrease from Class II to Class VII. Therefore it is not cost effective to use a conservation practice which is suitable for Class V in a Class II soil situation. It is also necessary to have soil conservation treatments which can fit into the socio-economic environment and allow maximum use of the land.

6.3.4 *Proposed Treatment-Oriented Land Capability Scheme*

In the Caribbean farmers are forced to cultivate soils outside of the historical capability classification proposed by the RRC because of scarcity of land, market demand and better prices for certain commodities. If the authorities were to enforce land use in accordance with this scheme many farmers would be forced out of farming and the nations would be unable to meet their food production expectations.

A treatment-oriented land capability scheme is needed. This would allow crop production on the steeper slopes provided it is associated with appropriate crop and soil management. A treatment-oriented land capability scheme would permit marginal lands to be used beyond the capability proposed by the RRC in their Soil and Land Use Surveys, through the introduction of suitable crop and soil management systems. It would bring more soils in Classes IV - VII into greater and sustainable agricultural production.

The scheme being proposed would classify soils in each slope category into different classes of fragility based on soil factors, for example, depth of soil, erodibility, and fertility status. Appropriate soil management treatments would then be proposed for crops or crop combinations on the soil. A treatment oriented or management scheme which would permit steeper slopes to be more intensively cultivated is presented in Table 6.3.3.

TABLE 6.3.3: Recommended Soil Conservation Practices Guidelines

SLOPE		TYPE OF CROPS OR CROPPING SYSTEM	RECOMMENDED PHYSICAL SOIL CONSERVATION PRACTICES
Degree	Percentage		
0 - 4	0 - 7	Best lands for intensive annual production; mechanized mono-cropping	Good crop husbandry; Contour farming
4 - 10	7 - 18	Good for intensive annual crop production; mixed cropping on erodible, fragile soils	Vegetative barriers; Hillside ditches
10-20	18 - 36	Semi-permanent crops; Annual crops suitably intercropped with semi-permanent or permanent crops	Storm water diversion and downhill drains; Vegetative barriers; Hillside ditches; Mini-terraces; Narrow ridges and furrows; Mulching
20-30	36 - 58	Permanent crops, for example, fruit trees in pure stands with grass ground cover, or mixed with food crop on the less fragile soils; agroforestry	Hillside ditches; reversed sloping narrow terrace; Tree basins especially at the higher slopes; relay cropping of food crops
30 - 45	58 - 100	Production Forest; Agroforestry on the less fragile soils *(Forest species and permanent fruit trees only)	Full ground cover always; soil conservation measures in association with agroforestry depending on crop mix
45+	100+	Forest for watershed protection	Full ground cover always

Some fruit trees, for example, mango, papaya, are not suitable for the high wet elevations because of disease problems.

The above general and summary guidelines should be used to develop specific recommendations for the different soils on various slopes and climatic conditions.