CHAPTER 2

SOIL EROSION STATUS AND SOIL CONSERVATION PROGRAMMES IN THE CARIBBEAN

2.1 Soil Erosion Status

The amount of soil erosion occurring in the Caribbean has not been quantitatively determined. Visual observations on soil sediments in streams, rivers and the sea, particularly immediately after a rainstorm, siltation of water courses and the depth of topsoil have been used to assess erosion status. The severity of soil erosion depends largely on topography, rainfall, natural vegetation, erodibility of the soils, land use and soil management.

Several Caribbean islands are characterized by steep slopes with a high percentage of the land area having slopes greater than 30° (58%). Many slopes are greater than 45° (100%) and farming is practised on these steep slopes. The distribution of slope classes in selected Caribbean islands is shown in **Table 2.1**.

Rainfall is largely influenced by the moisture laden northeastern Trade Winds and topography, so that rainfall decreases from the windward to the leeward coasts and increases with elevation. It is higher on the more mountainous islands than on the flatter islands. Annual rainfall can vary from a low of 625 mm on the leeward coast of relatively flat Antigua to a high of about 7500-8000 mm in the wettest area of Dominica. The amount of rainfall in the other islands is between these two extremes and a common range is from about 1300 to 3000 mm. Total annual rainfall is not only high but precipitation can be intense. Intensities of 25-127 mm per hour (and occasionally higher), have been recorded. Strong winds frequently accompany the storms thereby increasing the erosivity of the rainfall. Hurricanes which can and do occur, cause tremendous soil losses. Studies in Trinidad (Lindsay and Gumbs, 1982) have shown that two major storms (non-hurricane) of 49.8

TABLE 2.1: Distribution of slope classes in selected Caribbean islands

Slope Class %	Antigua ha	Antigua %	Dominica ha	Dominica %	Grenada ha	Grenada %	Trinidad ha	Trinidad %	St. Vincent ha	St. Vincent %	
A	1120	4.3	4450	8.1	480	1.6	110400	22.7	1225	5.1	]A]+
B	12290	47.0	1590	3.0	1020	3.4	39835	8.2			]B
C	5525	21.1	6120	11.3	1470	4.9	84070	17.3	4900	20.7	]C]+
D	5170	19.7	15340	28.2	5755	19.2	101755	21.0			]D
E	1940	7.4	18780	34.5	14285	47.6	62765	12.9	5715	24.1	
F	145	0.5	8080	14.9	6980	23.3	86730	17.9	11840	50.1	

Slope Class	Degree	%	Description
A	0 - 2	0 - 3	Level
B	2 - 5	3 - 9	Gently Sloping
C	5 - 10	9 - 17	Moderately Sloping
D	10 - 20	17 - 36	Strongly Sloping
E	20 - 30	36 - 58	Steeply Sloping
F	> 30	> 58	Very Steeply Sloping

and 75.7 mm during the year accounted for between 70 and 90% of the total annual soil loss depending on soil slope. The annual soil loss varied from 28 to 55 t/ha.

All the primary vegetation has been removed or lost from the islands as a result of hurricanes, shifting cultivation, fires and deforestation for human settlements and other uses. The secondary vegetation is not as protective of the soil against erosion as the primary vegetation.

Some of the sloping soils are prone to landslippage and are therefore erodible. In Trinidad, Jamaica and Barbados substantial areas of steeply sloping soils are developed on shales and in these soils landslips are common. Landslips are also common where soil is developed on impervious calcareous clays or impervious indurated and cemented clay or ash layer as in the case of the shoal soils of Grenada and some locations in the volcanic islands, for example, Dominica and St. Lucia. Many soils are, however, not inherently very erodible. Their good soil structure and high infiltration rates reduce their erodibility. However, the intense rainfall, steep topography and poor soil management result in high soil losses overall.

Although the rainfall, vegetative cover, soil type and topography are factors which contribute to the high soil losses by water erosion, it is inappropriate land use and poor crop and soil management which are the most important factors. Most of the farmers cultivate small farms on hillsides, usually steep slopes, without adequate or the most appropriate soil conservation methods. Shifting cultivation by squatters, clear felling and slash-and-burn cultivation increase erosion since the land is bare at the start of the wet season. It takes some time for the crop to grow sufficiently to protect the soil.

The occurrence of surface erosion, gullying, landslips, the amounts of eroded soil carried by streams and rivers during and after a heavy rainstorm and the depth of topsoil or shallowness of the soils have been used to qualitatively assess the severity or status of soil erosion in the Caribbean. A brief summary is presented below, using the grouping of the islands set out in Section 1.

2.1.1 Group One (Antigua and Barbados)

Antigua

Erosion is not as severe in Antigua and Barbuda as in many other parts of the Caribbean because of the relatively level topography and low rainfall (Hill, 1964). However, much accelerated erosion has occurred in the hilly areas of Antigua. Cotton which was grown extensively and requires a long fallow period, was generally grown under poor management. Consequently, erosion has been reported even on the more gentle slopes. Monoculture of sugar-cane in the past has also added to the loss of much soil in hilly areas. The dry season is often long and harsh and torrential rains often occur after long periods of drought when vegetation is sparse. This has contributed to the erosion problem. Overgrazing under the climatic conditions of Antigua and during times of poor vegetative cover and growth is another cause of accelerated erosion. The result of these factors is that the soil in many places has been eroded to such an extent that the topsoil is shallow or completely lost and rock outcrops are prominent.

Barbados

About eighty-five percent of Barbados occupies relatively flat coral soils on which erosion is not considered to be severe although Vernon and Carroll (1967) did suggest that erosion control measures may be necessary on the soils of the upland plateau of St. John's Valley.

In the hilly Scotland District, erosion is very severe. Cumberbatch (1969) reported that it was estimated that seventy percent of the area was threatened by erosion and that eleven percent of it had reached a very severe state of degradation. Land slides and gullying are common.

2.1.2 Group Two (Dominica, Grenada and Carriacou, Monsterrat, St. Kitts and Nevis, St. Lucia, St. Vincent, Tobago)

Dominica

Dominica is characterised by steep slopes where 86% of the land area has slopes greater than 20° and only 2% of the land has slopes between 0-5°. Over 66% of the land is covered by forests and rainfall is heavy i.e. average of 4450 mm per year and 7500 mm in the wet interior (Caribbean Conservation Association, 1991).

Most of the soils are generally highly permeable and therefore erosion is not as severe as might be expected given the steep mountainous topography of the island. Slopes greater than 50° (120 %) are cultivated without much erosion, indicating the unusual stability of the soils (Lang, 1967). In addition, erosion is limited because much of the land is still under forest.

Most of the shoal soils and other soils of low permeability occur on the leeward side of the island. Erosion of these soils is widespread and significant. Poor crop and soil management have been the major reasons for the erosion. The slow regeneration of soil suitable for cropping in the dry areas, like in St. Lucia, increases the seriousness of the problem.

According to the Environment Profile of Dominica prepared under the aegis of the Caribbean Conservation Association, 1991, Dominica has great potential for agricultural development without substantial incursions into forest lands which are more suited for other purposes. In the pre-independence period before 1978, large estate ownership was dominant (1.4% of farmers occupied 56.4% of the land and 61% of the acreage had farm sizes 50 acres and over). Since independence, large estates have declined in importance and have been either divided and sold or in some cases, left to lie idle due to absentee landlords. Demand for land has resulted in Government distribution of crown land to farmers, usually in lots of less than 4 hectares. Through Government's, Integrated Rural Development Programme (IRDP), and other land reform projects, several estates have been divided into small plots and distributed among local tenant farmers e.g. Carholm in the centre of the island;

Melville Hall, Castle Bruce and Newfoundland in the east; Geneva, Bagatelle and Petite Saavane in the southeast; and Soufriere in the south.

These programmes have not always prevented further encroachment into neighbouring forested areas. Also since 1978, a sizeable portion of forest has been turned into agricultural land. In Dominica's National Structure Plan (GOCD, 1985) a substantial amount of "unutilized" land is to be transferred to more intensive use (including agriculture) by the year 2001. This changing pattern of land use has implications for soil erosion and conservation.

Forestry and forestry development are important to Dominica. Timber extraction is undertaken but according to Russel (1974) it damages only a relatively small area and the erosion caused is not significant. In discussions with current officers in forestry and agriculture in Dominica, this view still seems to be valid. The view is that soil loss from logging is not severe because of selective felling. The exception is where lands are being brought into agricultural production and there is clear felling for extraction of forest species before land preparation.

The introduction of the chain saw and the clearing of land for agriculture throughout the year (with little attention to seasonality) has accelerated erosion. The removal of plantation tree crops and substitution of mixed cropping is also a contributor. The cutting of roads to make agricultural lands more accessible without proper consideration of soil type, road cutting techniques and road engineering has aggravated the problem. The expansion of agriculture has led to the increased utilization of marginal lands (e.g. steeper slopes, shallower soils) and this has led to greater erosion hazards.

Grenada and Carriacou

Grenada has suffered less from erosion and fertility exhaustion than many of the other islands. The two main reasons for this are:

(a) the island's agriculture is based largely on tree crops, cocoa (***Theobroma cacao***) and nutmeg (***Myristica fragrans***). Banana and

food crops are frequently interplanted with, for example, cocoa, and major forest fires are not prevalent;

(b) the soil parent material is very base-rich and the soil has been further enriched by additions of volcanic ash from eruptions in nearby islands in recent times. Thus, even if some surface soil is lost, the underlying exposed material is almost as fertile and promotes rapid vegetative growth.

Although cocoa and nutmeg are not a guarantee against erosion, they cause less erosion than under less permanent crops. Some severe erosion is nevertheless evident on hills where factors conducive to erosion exist, for example, land clearing, shifting cultivation, charcoal burning, fragmentation of land, poor land distribution, squatting, land tenure problems, and poor cultivation practices. Gullies frequently develop in nutmeg fields as a result of the nature of the soil and clearing of the ground cover for nutmeg collection. The neglect of these small gullies can lead to the rapid development of large gullies. In Grenada, significant landslips occur in some soil types. Examples of a significant landslip in Grenada are shown in **Figure 2(a)** and **(b)**.

In contrast, Carriacou has suffered very severe erosion over nearly the whole island and in many cases only the parent rock remains. This situation has been created by the erodible nature of the soils, cutting down of the original vegetation, using unsuitable cultivation methods and over grazing. Over grazing has been aggravated by the **"let go"** season when animals are allowed to roam freely. This has encouraged denudation of vegetation, soil compaction, reduced infiltration and erosion. The low annual rainfall which does not promote rapid vegetative growth aggravates the problem of overgrazing and denudation. Extensive cotton growing in the earlier years with poor soil management practices played an important role in aggravating soil erosion.

The soils of Cariacou are skeletal soils over ash and agglomerate, soils formed from other igneous rocks, and those formed from limestone. They are all susceptible to erosion and deep gullies are also evident on some of the flatter coastal areas.

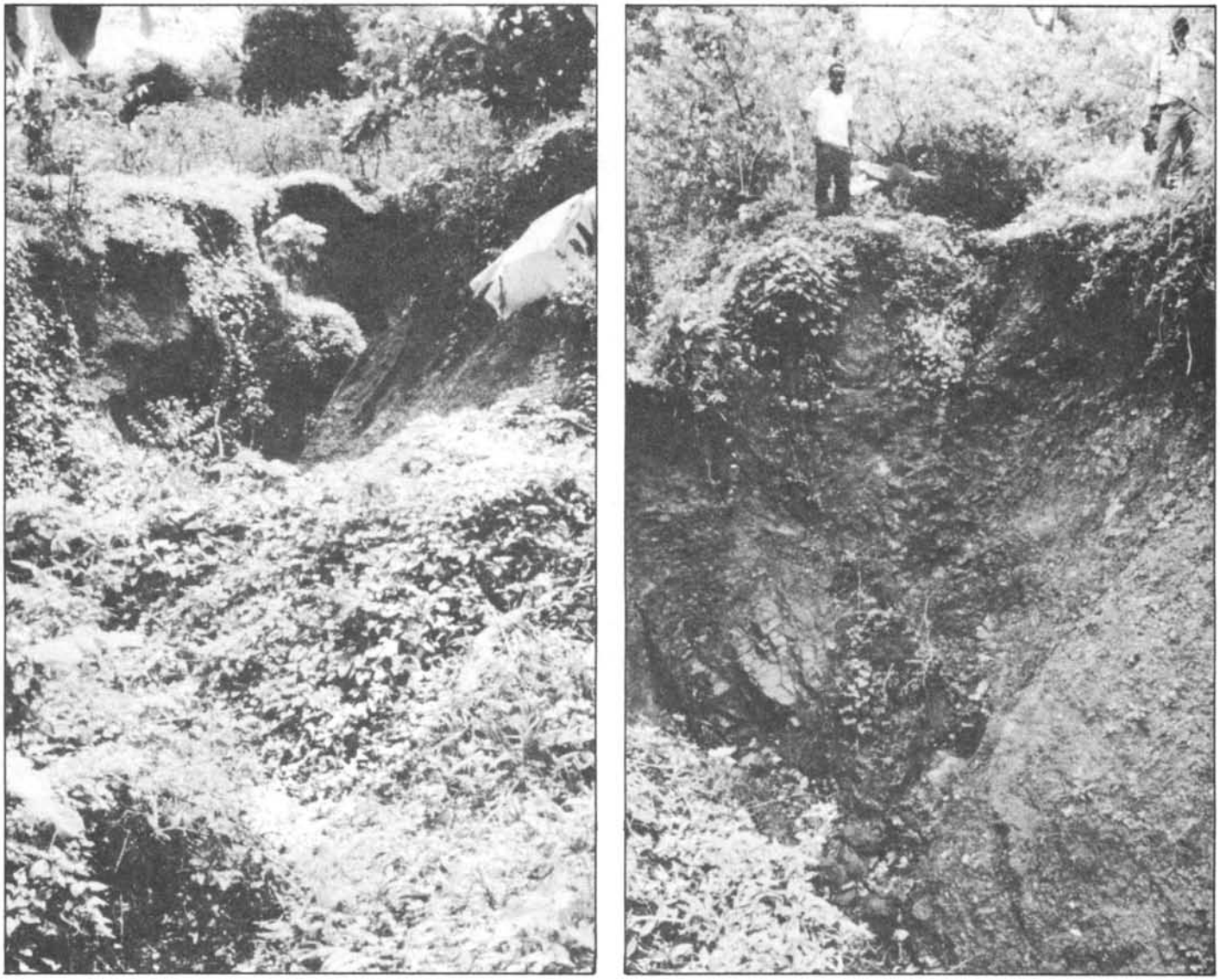

Figure 2 Landslips in Grenada

Montserrat

Lang (1967) describes the whole island of Montserrat as suffering from severe soil erosion and the greater portion of the island as having lost all its topsoil. The extensive monocrop cultivation of cotton in the 1940's and 1950's under poor soil management has contributed significantly to the widespread erosion. Unlike the soils of Dominica, the soils of Montserrat are generally unstable and many soils are highly erodible if cultivated on slopes greater than 10° (18%). The assessment of Lang may be harsh but the level of erosion is severe without a doubt.

Montserrat is an island of mini-farms which offers a challenge to effective soil conservation and to conservation on a watershed basis. This is not unique to Montserrat. Effective conservation in this situation requires the cooperation of many farmers. This is aggravated by the fact that farmers mostly practise clean cultivation of vegetable and food crops (e.g. root crops and tuber crops) on steep slopes which leave the fragile soil exposed to erosion. Relay-cropping is seldom practised and the standard of soil conservation is not high.

St. Kitts and Nevis

The retention of forest cover in the mountainous areas of St. Kitts has served to reduce erosion (Lang and Carroll, 1967). Where the forest has been cleared and planted to crops, some accelerated erosion is seen. However, since the soils are very permeable and free draining, erosion is not severe. The extensive growing of sugar cane helps to reduce erosion except during the period when the fields are cleared for replanting before the wet season arrives.

On the island of Nevis in contrast, much erosion can be seen. In many areas and particularly on the smectoid soils, the surface soil has been lost completely. This situation was caused primarily by poor farming practices and the widespread cultivation of cotton under poor soil management.

St. Lucia

Soil erosion is a major problem in St. Lucia. Many of the soils of the interior are very susceptible to erosion and during heavy rains soil can be seen being washed away by even the smallest rivulets (Stark *et al.*, 1966). In areas of allophanic clay soils, slumping is a problem and gullying is also common throughout the island. The common practices of clean cultivation of very steep land and of clearing steeply sloping forested land which would better be left under its original vegetation have accentuated the situation. Probably the most severe effects of erosion are on the so-called "shoal soils" (Vertisols) which contain a layer of indurated material in the subsoil. Once the surface soil has been lost it is impossible to grow crops on them and regeneration is very slow since these soils occur in the drier parts of the island. Large areas of land formerly under cultivation have been misused to such an extent that they have been abandoned and left idle for many years. Rehabilitation may be very difficult or impossible.

St. Vincent

The soils of St. Vincent are entirely of volcanic origin. Four major soil groups are recognized (a) High- level and Low-level Yellow Earths developed over massive rock; (b) Recent Volcanic Ash soils; (c) Shoal soils and (d) Alluvials. Because of the high permeability of the soils, they are not easily eroded under natural vegetation. The Yellow Earths are well structured soils and not naturally erosion prone. However, several of the soils in this group have relatively shallow topsoil and the parent material or "rotting" rock can be found within 0.50-0.75 m of the soil surface. The saturation of the topsoil in the wet season and the shallow rooting systems encourage land slippage. The soils are erosion prone when denuded of vegetation or poorly managed. Land slippage also occurs in the shallow shoal soils. The Recent Volcanic Ash soils (developed over cindery materials) are more prone to gullying than surface wash (sheet erosion). Nevertheless, sheet erosion is common under poor soil management.

Soil erosion is, however, considered to be a serious problem in St. Vincent, because of the types of crops grown and the deficient or inadequate crop and soil management (Watson *et al.*, 1958). Clean cultivation of root crops, groundnuts, banana, (and previously cotton) without adequate soil conservation has encouraged erosion. Cultivation of root crops and groundnuts entails a great deal of disturbance of the soil and relatively long periods in which much of the soil is left bare.

Many farmers of St. Vincent have traditionally practised soil conservation which, for many years, represented the best examples of soil conservation in the Commonwealth Caribbean. This was a consequence of the policy of the Government to financially support or subsidize soil conservation. With the decline in Government subsidy the standard of soil conservation has declined and there is evidence of increased erosion and siltation of water courses. The expansion of annual cropping and banana cultivation to very steep slopes which should remain in tree crops or forest has also increased erosion in recent times.

Tobago

The soils of the mountainous area of Tobago are formed from parent materials such as volcanic tuffs, breccias, diorite and schists and are highly prone to erosion. The northern and wettest end of the island is still under original forest or permanent tree crops so that erosion is restricted. Further south, erosion is a more serious problem. Hardy has described heavy erosion in the Castara-Palatuvier area on the leeward side of the island where intensive peasant and estate cultivation was carried out. At present, the topsoil is very thin in many places and much of the land has been abandoned and has reverted to secondary growth. A few farmers still persist with limited subsistence crop production on the less eroded and less steep slopes.

On the windward side of the island, land on the volcanic soils are cleared, mainly by burning, and planted to arable crops. Evidence of sheet erosion, gullying and soil slump can be seen throughout the area wherever the land has been cleared.

The most eroded area of the island is the Mason Hall-Les Coteaux district. The sandy clay loam soils of this area formed from diorite is very irregular, steeply sloping and highly erodible. The degradation started more than one hundred years ago when they were cleared and used continuously for sugar cane cultivation. After the collapse of the sugar cane industry in Tobago the lands were settled by shifting cultivators. Today, the drier parts of the area resemble a desert while the wetter parts are covered with scrub vegetation. In spite of this degradation some areas are still cleared regularly and planted to row crops. Frequently, a fire started in the drier parts to clear a small patch for planting will spread widely, leaving the soil bare for the heavy rains of the wet season. Fortunately the parent rock weathers quickly to a friable easily worked material which will support limited cropping. If the land is not cropped too often, there will always be some soil left on which some cropping can be carried out. Similar erosion damage on the more slowly regenerating volcanic rock or schist would have been more disastrous to crop production.

Limited soil conservation is practised mainly in the form of intercropping and occasionally trash mulching. On eroded soils the topsoil is shallow and parent material may protrude on the soil surface. Some soil series have a distinct eroded phase of low fertility and restricted cropping potential.

2.1.3 Group Three (Jamaica and Trinidad)

Jamaica

Soil erosion is rampant and severe in many parishes and on many soils of the island. One of the major factors is population pressure which results in increasing frequency and intensity of land use or the use of land beyond its capability. The parishes of Westmoreland, Portland, Hannover, Clarendon and St. Elizabeth are especially noted as suffering severely from accelerated soil loss, but serious erosion is noted in all parishes. Soils on which erosion is a serious problem are the limestone soils, shale-derived soils and the soils formed on grano-diorite.

The shale soils are noted for their shallowness, poor infiltration and permeability, factors which contribute to serious erosion problems. They are

among the most important soils in areas of extreme soil erosion such as Christiana and Yallahs Land Authority.

One serious consequence of extensive erosion is the common flash flooding in the plains of many areas after heavy rains. The flash floods themselves cause much damage to crops, livestock and property.

Trinidad

The earliest comprehensive report on soil erosion in Trinidad was by Hardy (1942). He reported considerable gullying and sheet erosion in the foothills of the Northern Range, particularly in the west where intensive cultivation was being carried out. Burning to clear the land for planting at the start of the wet season is common and landslips are frequent. In some places the soil surface is within 15 cm of the parent rock. In the Las Lomas district, the sandy soils are described as being very erodible, but since much of the land is in forest reserve, erosion is not such a severe problem. In the Central Range, land creep is a major problem and the southern slopes show many landslip scars. Chenery (1952) mentioned that Brasso clay, the most widespread soil of the Central Range, is very eroded due to prolonged cultivation up and down slope. He also mentioned that Montserrat clay, a very productive cocoa soil, is highly prone to gullying.

Both Hardy and Chenery commented on the severe erosion of the marl soils and the associated red soils of the Naparima District in southern Trinidad, with caps of exposed white marl being a common feature of the hills of the region. In the Southern Range where soils are derived mainly from sandstone, erosion occurs wherever the original forest cover has been removed.

There has been no comprehensive nor sustained programme of soil conservation. Poor agronomic practices have persisted so that topsoil continues to be lost especially from soils in the Northern Range and the topsoil is now shallow in many locations.

2.2 Soil Conservation Programmes

Many soil conservation projects or programmes have been undertaken in the Caribbean, sometimes at considerable cost, to protect the soil against erosion, to train farmers and agriculturalist in methods of soil conservation, to facilitate production on hillsides and to increase the productivity of hillsides. This effort has been greater in Jamaica than any other Caribbean island. The problems, however, are still many and serious and much remains to be done. The Government of Jamaica through the relevant Ministries and Statutory Agencies has undertaken various watershed protection activities e.g. reafforestation on public lands, establishment of permanent tree crops and engineering works for gully control, river training and drains.

Gumbs (1992) reviewed the soil conservation projects undertaken in the Caribbean over the previous 20-25 years and assessed the successes and failures of these projects. A brief summary of the major projects undertaken is presented below.

2.2.1 *Barbados*

The Scotland District was the target of most of the soil conservation effort. The main approach has been the use of engineering methods requiring earth moving equipment for land reshaping and stabilization, construction of terraces, dams and silting ponds, surface and subsurface drainage, the construction of gabion weirs and gabion boxes, and reafforestation. This was costly and when Government and International funding ended, farmers were unable to maintain the effort. Farmers' plots are also small and non-contiguous and limit implementation. In some cases reshaping of the land aggravated and increased erosion because the reshaped land was often more prone to land slippage and surface erosion than the original. In addition, toxic oil and salt from the subsoil were sometimes exposed at the surface during reshaping.

2.2.2 *Grenada*

The largest and most significant project was the UNDP/FAO project which was implemented over the period 1975-1985. However, most of the soil and water conservation methods required costly earth moving machinery and were labour intensive. The terraces were costly to construct and had to be used continuously to justify the cost. Farmers did not adopt the methods and the demonstration effect failed.

2.2.3 *Dominica*

There has not been any major projects specifically dedicated to soil conservation which have received international funding. The country has, however, been soil conservation conscious and the farming practices reflect this. The use of tree crops has been a major component of the approach to soil conservation.

2. 2.4 *St. Lucia*

The main projects undertaken were:

(i) Soil and Water Conservation Project funded by the European Development Fund. The major thrust was drainage and land reclamation.

(ii) Development of Soil Conservation Practices for Small Farms funded by CIDA through Mc Gill University. The main aims were to establish a soil conservation demonstration, training and research field site, and to upgrade the technical capability of staff of the Ministry of Agriculture, St. Lucia. The demonstration effect was not successful, the site was not maintained after the project ended, and farmers did not adopt the methods.

(iii) Mabouya Valley Development Project. This project is ongoing and has shown promise of continued adoption and potential for sustainability. The approach adopted by the project of providing incentives and promoting community involvement and participation seems to be an important reason for the achievements so far.

(iv) Forest Management and Conservation Project is funded by CIDA and was projected to terminate by the end of 1992. In the project three sub-watersheds were selected for rehabilitation in a pilot phase and to provide a model for extension to other areas. The project has not been finally evaluated but the approach of involving the entire family, the community, national farmers association, social considerations, avoidance of the gratis mentality, and provision of institutional supports to the farmers, seems to be contributing, to the success of the project.

(v) Locally Funded Soil Conservation Projects of the Land and Water Use Unit and the Forestry Division of the Ministry of Agriculture.

2.2.5 *St. Vincent*

(i) Cumberland Watershed Management Project which was undertaken 1984-1989 was the major soil conservation project. It was a complementary project to the Cumberland Hydro-Elective Project funded by USAID, and the main objectives were to maintain good watershed conditions, intensify agricultural and forestry productivity without soil degradation, and extend the experience to other critical watersheds. The project was not very successful for many reasons which have been discussed by Gumbs (1992).

(ii) Small Holder Crop Improvement Project is in progress (1990-1997) and is funded by the International Fund for Agricultural Development (IFAD). It has a soil conservation component which is outlined by Gumbs (1992).

(iii) Watershed Management Plan for the Colonarie River Basin is currently being formulated (1990-1995) with funding from CIDA. The project is essentially an inventory, capability assessment and planning exercise for the Basin. It proposes to develop management plans, proposals for farming systems and soil conservation. However, it is not clear how comprehensive and implementable they will be.

2.2.6 *Jamaica*

The following major projects have been undertaken or are being undertaken:

(i) Forestry Development and Watershed Management in the Upland Regions (1968-1975) funded by FAO;

(ii) First Rural or Kenilworth Project (1971-1977) funded by UNDP;

(iii) Second Rural or Second Integrated Rural Development Project (1978-1983) funded by USAID;

(iv) Projects of the Soil Conservation Unit and Land Authorities;

(v) Strengthening the National Soil Conservation Programme for Integrated Watershed Development (1979-1982) funded by UNDP, Norway and Government of Jamaica;

(vi) Hope River Watershed Project was initiated in 1987 and consisted of three Phases. It is still ongoing;

(vii) Small Farm Credit Project (1989/90-1996) is funded by IFAD. Funds are provided to the Agricultural Credit Bank (ACB) and People's Cooperative Banks for lending to small farmers. A specific Hillside Farmers Support Project in which soil conservation was to be an explicit requirement of the project was undertaken.

(viii) Hillside Agricultural Project (HAP) and Hillside Agricultural Sub-Projects (HASP) implemented under HAP. This project was initiated in 1987 and is due to terminate in 1994. It has shown some degree of success and is specifically reviewed in Chapter 8.

(ix) The Sustainability of Contemporary Agricultural Land Use in the Blue Mountains of Jamaica was initiated in 1991 and is proposed as a three year project.

The majority of projects have failed to achieve their objectives of adoption and sustainability of soil conservation by farmers. Many of the reasons are sociological and, to a lesser extent, administrative and technical. These are discussed in the succeeding chapters.