

**Integrating Management of Watersheds & Coastal
Areas in Small Island Developing States of the
Caribbean**

NATIONAL REPORT

for

Antigua & Barbuda

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Executive Summary

The islands of Antigua and Barbuda, located in the northern Leeward Islands, are characterised by relatively low relief and upper watershed lands that were deforested and degraded through two centuries of sugar cultivation. The low average rainfall and highly erratic distribution, as well as the shortage of suitable surface or ground water storage areas, have combined to produce a situation where the country is severely short of fresh water to supply even domestic needs in drought years. This has led to increased reliance on desalinated water to supply domestic needs, but has left the agricultural sector with very minimal resources for irrigation. Climatic changes resulting from global warming are predicted to make both the supply and demand situation worse.

Given the critical nature of the fresh water resource, it is surprising that so little priority has been accorded to watershed management. There are no effective laws relating to watershed protection and no watershed reserves have been declared. There has been little or no attempt to reforest denuded hillsides, despite acknowledged problems of siltation and erosion in some valleys. Burning and overgrazing of hillsides continue to be a significant source of watershed degradation in several areas. The Forestry Division remains very under-staffed and under-funded and with no clear mandate to manage the upper watershed areas.

At present, approximately one third of the domestic water supply is obtained from surface storage or ground water aquifers. Shallow reservoirs and high rates of evapotranspiration lead to significant loss of surface stored water. The last major investment in fresh water storage capacity was more than 30 years ago. Salt water intrusion into groundwater supplies is a problem in several aquifers, especially during times of drought when extraction is excessive.

Other demands on the watershed lands include their use for cattle pasture, especially during times of drought when other areas are overgrazed. Some of these areas are burnt to provide young re-growth of the coarse grasses, which are more palatable for the cattle. There are considerable populations of semi-feral goats which depend on the forest and scrub lands for fodder. This has resulted in the removal of much of the understory growth and loss of forest regeneration in places where the grazing pressure is high. In addition, the forest areas provide a source of forest products, such as wattle, for fishpot construction, as well as wood for charcoal making. These uses are uncontrolled and may be at non-sustainable levels in some areas.

In the lower watershed areas, food crop and livestock production is carried out, often in close proximity to surface reservoirs or groundwater supplies. Concerns have been raised about the possibility of pesticide contamination of water supplies or leaching out into the coastal zone in times of heavy runoff. A lack of pesticide monitoring capability has prevented any proper assessment of this risk.

Due to the short length of all watersheds and the rapid runoff during rainstorms, silt load and pesticide contamination are expected to produce problems in the coastal zone, especially in those watersheds where the natural protection of mangrove wetlands has been removed by coastal development.

Besides these threats from watershed runoff, the coastal zone is under considerable stress from tourist related development along much of the coast. Siting of structures too close to the natural waterline as resulted in beach erosion. Destruction of wetlands to construct hotels, marinas and other tourism related facilities, has put stress on the whole near-shore ecosystem, increasing turbidity, removing fish breeding habitats and food supplies. Increased fishing pressure in the inshore areas has added to the stress and fish catch is declining. This may also have been contributed to by increased levels of

pollution from improperly functioning sewage treatment plants used by hotels situated on the coast and wash off from urban areas, particularly St. John's harbour, which is heavily polluted. An increased incidence of hurricanes and tropical storms, experienced over the last decade, has also had a deleterious effect on reefs, mangroves and seagrass ecosystems.

Integrating the management of watersheds and coastal areas will require the input of considerable resources in order to provide the legal and institutional support that will be needed. A major obstacle to real progress is the lack of understanding at all levels, from policy makers to the general public, of the function and importance of watersheds and how the relatively slow processes of land degradation lead to the downstream degradation of coastal ecosystems and their associated fisheries resources.

Currently, many agencies have responsibility for various aspects of watershed and coastal zone management, although watersheds are hardly recognised, as such, in any legal or institutional arrangements. The level of cooperation among these institutions, government, parastatal and community or user groups, is very variable and depends largely on working relationships between individuals in the respective agencies. Sometimes this can work well, but is subject to instability when personnel changes take place. Traditionally, watersheds and coastal ecosystems have been managed by quite separate agencies. However, the need for a "ridge to reef" approach will have to be reflected in the new legal and institutional arrangements that will be needed to provide effective integration of watershed and coastal zone management and the coordination and rationalization of the many agencies responsible for various aspects of watershed and coastal zone management.

The legal support for management of natural resources is, in general, quite out of date, fragmented and provides inadequate force to be effective. The legal officers, themselves, are often not well informed on the consequences of damage to natural systems and habitats. Certain improvements to legislation governing land use, forestry, fisheries and control of toxic substances are in the pipeline, but progress has been very slow. No attempt has yet been made to look at legal issues for watersheds and coastal areas as a whole.

Effective management of both watersheds and coastal areas has been constrained by a lack of basic scientific information on the status of these ecosystems and the results of various pressures to which they have been exposed. Adequate data collection, processing and storage in accessible systems remain a pressing need. Present levels of human and physical resources are insufficient to provide the monitoring that is necessary.

New ways of revenue generation are required to support the management systems that are required and it is proposed that greater attention to cost recovery for services provided to the tourism sector should be pursued.

A plan of action to be supported by the project is proposed, which focuses on increasing general awareness of the function of watersheds in providing water resources for the nation and in protecting the fisheries and coastal ecosystems on which tourism is so dependent. The concept of a model watershed is outlined as a vehicle to raise awareness by visible demonstration and at the same time to address, in a local context, the many management and technical issues that have to be solved at a national level, if watersheds and coastal areas are to be managed in a more integrated and functional manner, thereby maximizing the sustainable use of these indispensable natural resources.

It is also suggested that there is a need to set up a regional system for monitoring levels of toxic substances in soils, aquatic and coastal environments. National capabilities to collect and prepare samples would be supported by regional laboratories with a mandate to provide specialist analytical

services. This would be particularly helpful to the smaller territories of the Eastern Caribbean which do not have the resources, physical or human, for many types of pesticide analysis.

List of Acronyms

AF	acre foot (1233 m ³)
APUA	Antigua Public Utilities Authority
CBD	Convention on Biological Diversity
CBH	Central Board of Health
CBO	Community Based Organization
CEHI	Caribbean Environmental Health Institute
CIDA	Canadian International Development Agency
DCA	Development Control Authority
GARDC	The Gilbert Agricultural and Rural Development Centre
GDP	Gross Domestic Product
GIS	Geographical Information System
GPS	Geographical Positioning System
MAL&F	Ministry of Agriculture, Lands and Fisheries
MARPOL	Marine Pollution Agreement
MG/M	million gallons/month
NDNP	Nelsons Dockyard National Park
NGO	Non-Governmental Organization
NODS	National Office of Disaster Services
NPA	National Parks Authority
NRMU	Natural Resources Management Unit (OECS)
NSWMA	National Solid Waste Management Authority
OAS	Organization of American States
OECS	Organization of Eastern Caribbean States
WTO	World Trade Organization

1. Introduction and Background

1.1. *General Physical Characteristics of Antigua and Barbuda*

1.1.1. General Features

The islands of Antigua and Barbuda are located in the eastern arc of the Leeward Islands, between Guadeloupe and Saint Martin as shown in Figure 1.1, Antigua is situated at latitude 17° 10' N by 61° 55' W and the island of Barbuda is found 28 miles north of Antigua at 17° 35' N by 61° 48' W. Redonda, a small rocky island about 25 miles west of Antigua is uninhabited and will not be included fully in this report.

Antigua is roughly round in shape and occupies a land area of 280 sq. km. (108 sq. miles) while Barbuda is approximately two thirds this size, occupying 160 sq. km. (62 sq. miles). The location of important features of Antigua and Barbuda is shown in Figure 1.2

The island of Antigua is divided into three topographic zones, the mountainous south west region, the relatively flat Central Plains and the rolling limestone hills and valleys in the north and east. (See Figure 1.3a) The highest point in Antigua, Boggy Peak, 402 m (1,319 ft.) and the steepest slopes, are found in the South West zone. Here slopes of 11° to 20° are common and up to 30° are present in localized areas particularly around Tramontania and Sugar Loaf areas. Barbuda is relatively flat with some low hills rising to just under 40 metres (125 ft.) in the Highlands area. Slopes are mostly under 2° (See Figure 1.3b)

Antigua and Barbuda both experience a tropical maritime climate with little variation in daily or seasonal temperatures. Average monthly minimum temperatures range from 22.4°C in February to 25.4°C in August, while monthly maximum temperatures range from 27.9°C in February to 30.5°C in September. Slightly greater diurnal variation is observed in some inland areas. Relative Humidity averages range from lows of 72% - 78% in mid afternoon to early morning highs of between 81% to 85%. The drier conditions and lower temperatures are experienced during the months of January to April.

The islands lie in the path of the northeasterly Trade Winds and experience fairly steady winds off the Atlantic ranging from the NE to the SE. Monthly average wind speeds are 17 to 26 km/hour, with lowest speeds in September to November.

Rainfall is probably the most important and variable climatic feature and severe droughts are experienced every few years. Conversely, depending on the major climatic cycles associated with El Nino/La Nina, quite wet years are also possible. Average annual precipitation averages about 1050 mm (40 ins.), but has ranged from 667 mm to 1708 mm since 1960. Figure 1.4a shows annual rainfall totals for V C Bird Airport for the period 1960-1999. Monthly rainfall averages are provided in Figure 1.4b and these show that the months of January to April are the driest period while September to November are considered Wet Season months. These months coincide with the period of active tropical waves and tropical storms. May is particularly variable and while often quite dry also holds the record as the wettest month.

Rainfall distribution over Antigua is represented in Figure 1.5, which shows the drier areas located in the flatter eastern and northern regions and the highest rainfall areas in the mountainous south west.

Figure 1.1 Location of Antigua and Barbuda in the Eastern Caribbean.

See file: (figure1_1.pdf)

Figure 1.2 Map of main infrastructure for Antigua and Barbuda

See file: (figure 1_2.pdf)

Figure 1.3a. Topographic zones of Antigua

Figure 1.3b Topographic zones of Barbuda

See file: (figure1_3ab.pdf)

Figure 1.4a Annual rainfall totals for V. C. Bird Airport (1960-1999)

Figure 1.4b Monthly rainfall averages for Antigua (V. C. Bird Airport, 1960 - 1999)

See file: (figure1_4ab.pdf)

Figure 1.5 Annual rainfall distribution for Antigua (Isohyets in inches)

See file: (figure1_5.pdf)

Most precipitation is received in short lived heavy to intense showers, which increases erosion hazards on unprotected soils. Maximum rainfall in 24 hours recorded at V. C. Bird airport stands at 212 mm

Evapotranspiration rates are quite high due to the steady winds and high temperatures. These average between a low of 87 mm/month in November and a peak of 143 mm/month in March (McMillan 1985). On average, even in the wetter zones, like Greencastle, potential evapotranspiration exceeds effective precipitation (estimated at 70% of actual) in 11 months of the year, and vegetative growth is significantly constrained by lack of water in most years.

Rainfall data for Barbuda is much less comprehensive, but indicate that Barbuda is significantly drier, as would be expected from the flat topography, with annual average precipitation of 750 to 900 mm. (30 to 35 ins.)

In recent years, hurricanes and tropical storms have been much more frequent and damaging. Since 1995 Antigua and Barbuda have experienced four serious hurricanes and several tropical storms. Winds of up to 190 km/hr were recorded. Damage to infrastructure, vegetation and coastal features such as beaches and reefs has been significant.

1.1.2. Geology and Soils

1.1.2.1. Geology

Antigua lies on the older volcanic arc associated with the meeting of Atlantic and Caribbean tectonic plates and is the much altered remnant of a volcanic area which became inactive in the Upper Oligocene, about 20 million years ago. Geologically, Antigua can be divided into three regions running north-west to south-east. These are: 1) the volcanic region in the south-west, 2) the central plain and 3) the north-eastern limestone region. The volcanic region comprises hard igneous rocks in the uplands and sedimentary material in the associated valleys. The central plain consists of a mixture of agglomerates, tuffs, and conglomerates, together with some cherts and limestones. The limestone area in the north and east is geologically the most recent and is composed of a mixture of hard limestone and softer marly deposits of the Antigua formation. The geology of Antigua has been described in detail by Martin Kaye (1959).

Barbuda also has three geological regions:

- I. The Highlands Limestone area, mostly of hard limestones, which contain caverns and sink holes
- II. The Codrington Limestone region which contains sandy and fossiliferous sediments less crystalline than the Highland limestone
- III. The Palmetto Point Series. This overlies the Highlands and Codrington formations in coastal areas especially between Palmetto Point and Sand Ground and is composed of beach sands and ridges, with shelly horizons.

1.1.2.2. Soils

Soil formation has been influenced primarily by the different parent materials, land slope and the relatively dry climate. Soils have been mapped (1:25,000) and described in detail by Hill (1955). In

Antigua, the 33 soil series described by Hill may be conveniently grouped into five broad groups according to depth and texture (CEP 1991). These comprise:

1. Deep alluvial/colluvial soils in the valley systems of the volcanic region. These soils are primarily sandy loams or loams with near neutral pH. Some of the best tree growth is found in these soils
2. Deep kaolinitic clay soils of the Central Plain. These are hard to work, heavy clays with impeded drainage and near neutral pH. Some are saline at various depths below the topsoil. Some calcareous clays are found in parts of this region
3. Generally shallow calcareous clay soils of the limestone areas in the north. These are productive in the deeper phases over the softer marls. Despite the high clay content, they possess good structure and have high base saturation. Soil pH is around 8.2
4. Complex of shallow and deep calcareous soils, mostly in the eastern part of the limestone region. Similar to Group 3 but with greater areas of deeper soils. Drier climate restricts productivity.
5. Shallow soils of the mountainous volcanic region. These are thin to very thin, stony soils formed over andesite and basaltic rocks. They are mostly clay loams and clays of reddish brown colour with slightly acid pH. Steep slopes, erosion hazard and shallowness preclude use for other than watersheds, and forest cover.

Figure 1.6 shows the distribution of these soil groups. The deeper marl soils and the alluvial soils of the volcanic area are the most productive soils for agriculture and will support production of a range of vegetables and tree crops. Water remains the biggest limitation to agricultural production

In Barbuda, there are three main soil series corresponding to the three geological regions. The Barbuda series is found predominantly over the hard limestone of the Highland region and is composed of a reddish kaolinitic clay loam. The Blackmere series is found at lower elevations over hard limestone and is a brown clay loam. The Codrington series is found on the more recent terraces of hard limestone and is a dark coloured montmorillonitic clay. There are also extensive areas of very young soils developing on stabilized beach sands and dunes, where water holding capacity is very low and drainage is excessive.

1.1.3. Coastal Features

1.1.3.1. Coastline, Beaches and Reef Systems

Antigua and Barbuda are emergent parts of a 3,400 sq. km sub-marine platform, one of the largest in the Eastern Caribbean. The depth of water between the two islands ranges from 27-33 m. The coastline of Antigua is markedly indented with numerous islands, creeks and inlets and associated sand bars and wetlands at their inland end - (See Figure 1.7a). A large portion of the east, north and south coasts are protected by fringing reefs. Large areas of sandy bottom in shallow water are found on the west coast and between the fringing reefs and the shore. The Barbuda coastline is less varied but has extensive reef systems, especially off the east coast (Figure 1.7b). Codrington Lagoon in the north west is a large almost enclosed salt water lagoon bordered by mangroves and sand ridges with considerable importance to the fisheries and wildlife of Barbuda.

Figure 1.6 Distribution of main soil groups for Antigua

See file: (figure1_6.pdf)

Bacon has estimated the combined area of both reef systems as 25 sq. km. (Bacon 1984). Both islands have extensive coral sand beaches with relatively shallow off-shore waters.

1.1.3.2. Wetlands and Estuaries

Antigua and Barbuda have some of the most extensive mangrove wetlands to be found in the Eastern Caribbean. Antigua's major wetlands areas are displayed in Figure 1.8a and those of Barbuda in Figure 1.8b. An estimated 4,900 ha of mangroves and salt ponds were to be found in the two islands, (World Resources Institute, 1987). Several major wetlands have been removed through tourism based development in the last 20 years as shown on the maps. The Environmental Awareness Group has recently carried out a study of the remaining wetland areas in Antigua and identified XX sites occupying XX ha. Well developed mangrove woodlands are present in Parham Harbour, Fitches Creek, and Guiana Island in the north west while another important site is at Ayres Creek.

1.2. Socio-Economic Setting

1.2.1. Historical and Cultural Background

Antigua and Barbuda have a rich legacy of pre-Colombian sites and artefacts and were an important regional source of flint and chert for stone tool making. The colonial history of the two islands was somewhat less turbulent than other Leeward and Windward islands as British rule was only once briefly interrupted between colonization in 1632 and the country's attainment of full independence in 1981. The many safe harbours offered by Antigua's creeks and bays, notably English Harbour, and extensive reef system, favoured it as a naval base and made it difficult to attack effectively. Slavery and sugar are the two main threads of Antigua and Barbuda's colonial history. The production of sugar throughout the island starting around 1675 and lasting until the 1970s, has had an indelible effect on the population and the natural resources of the island. Slavery, as in other islands, was introduced to provide labour for the many sugar estates and lasted until abolition in 1834. However, the black population continued to live in deplorable conditions until the development of the labour movement began to turn the tide after World War II.

Barbuda was leased by the British to the Codrington family from 1668 until 1870 when it came under the control of Antigua, but has continued to have a somewhat separate existence, even since independence.

1.2.2. Population and Human Resources

The population of Antigua Barbuda was enumerated at the last official census in 1991 as 63,878, a figure marginally lower than the population in 1970 when the previous census was taken. Of the total, Barbuda contributes approximately 1,200 persons. The population density of 228 persons per square kilometer is somewhat lower than the OECS average, largely due to the low population density of Barbuda (about 7 persons per sq. km.). In 1984, nearly 60% of the population was recorded as living in the city and parish of St. John's, giving rise to a population

Figure 1.7a Map showing locations of main reef systems of Antigua

Figure 1.7b Map showing the location of main reef systems of Barbuda

See file: (figure 1_7ab.pdf)

Figure 1.8a Location of major wetland areas in Antigua

Figure 1.8b Location of major wetland areas in Barbuda

See file: (figure 1_8ab.pdf)

density of approximately 2,700 persons per square kilometre in the main urban area. The remaining population is relatively well distributed over the rural areas and highest population concentrations are on the coast. Average size per household is 3.2 persons

Despite minimal increases in population, increased affluence and mobility and smaller family units, have increased demand for most public services and utilities. Electricity, water and telephone usage has increased considerably in the last 10 years. The number of private vehicles has also increased significantly. All this is putting increased demand on the natural and physical resources available.

Unemployment is estimated at 7.8% (1998 figures) with seasonal shifts due to hotel closures or low occupancy during the off season. Unemployment is higher in Barbuda. There has been universal primary education since the mid-60's and school enrollment rates are about 95%. Adult literacy is estimated at 90%. Primary, post-primary, and secondary education, to CXC level, are offered at approximately 30 public schools and 12 private schools. Many private pre-schools have come into existence during the last fifteen years. There is one sixth form college which also teaches some first and second year courses for the University of the West Indies.

1.2.3. Physical Infrastructure and Public Utilities

Ever since the development of extensive naval facilities in Antigua in the Napoleonic period, Antigua has had better physical facilities than many neighbouring islands. Today, with the growth of the economy due to tourism, Antigua possesses an excellent communications and transport infrastructure, including international airport, deep water harbour, cruise ship berthing facilities, and extensive road network linking all parts of the island. Electronic communications are also well developed including cellular telephone services, with fibre optic and microwave linkages between major communication nodes, suitable for rapid data transmission.

Power generation and transmission have been extensively improved in recent years providing a relatively reliable, hurricane resistant service. Domestic water shortages such as those of the 1980's have been replaced by an expensive but more reliable water generation system that relies heavily on desalinated water to provide up to 60% of the daily requirement.

Barbuda's infrastructure lags significantly behind that of Antigua but is being upgraded. The small runway at Codrington Airport limits use to small aircraft with up to 20 passengers. Telecommunications are modernised, but roads are by and large unpaved.

The City of St. John's, located on the west coast, is the nation's capital, housing the market, major banking and commercial activity, as well as the Deep Water Harbour and cruise ship berthing facilities at Heritage Quay. Despite its high population density, St. John's still does not have a sewerage system although the ground is unable to accommodate the volume of septic tank effluent produced. English Harbour, on the south-east coast is the next largest urban center, servicing the tourist and yachting centres at Nelson's Dockyard and Falmouth Harbour. Another important yachting centre and marina is situated at Jolly Harbour on the west coast. Several villages along the coast and some inland are rural centres of population concentration. In recent years, the general rise in standards of living has seen movement of commercial activity outside St. John's and considerable expansion of housing into rural areas, such as Lightfoots, Buckleys and Langfords, leading to some loss of agricultural land.

Hotels and tourist activity are quite well distributed along the coast, with greatest concentrations on the west coast, both north and south of St. John's. This generally follows the distribution of the larger beaches around the island. In Barbuda, the two hotels are located near the southern tip of the island.

1.2.4. Economic Development

1.2.4.1. *Tourism*

Tourism has been the single most important factor in the recent development of the economy of Antigua and Barbuda and is now responsible for approximately 60% of the GDP. The growth of GDP over the period 1985 to 1998 has clearly followed the fortunes of the tourist industry. The damaging effect of hurricanes Luis and Georges was significant, both on tourism and the overall economy. During the period, the most important developments have been the construction of marinas and boating related facilities and the relative growth of cruise ship tourism.

1.2.4.2. *Banking and Offshore Industries*

Over the last ten years, and particularly since 1995, there has been a significant increase in offshore business in Antigua. This has included off shore banks and internet based industries in insurance, gaming and betting, benefitting from the high quality of telecommunications/internet connection services available.

1.2.4.3. *Industry and Business Sector*

The manufacturing sector's share of GDP has declined steadily from 4.1% in 1988 to 2.5% in 1998. The decline has been partly due to the faster growth of the tourism sector with which manufacturing has to compete for labour. High utilities costs have also had a negative effect. Difficulties in accessing regional or extra regional markets also limit expansion and cost reduction through economies of scale.

1.2.4.4. *Agriculture*

Agriculture continues to struggle with a series of constraints, including high cost of labour, small size of local market and lack of marketing structures and infrastructure, competition from imported foodstuffs, inadequate supply of water for irrigation as well as a regular succession of severe droughts and, in recent years, destructive hurricanes. Not least among agriculture's constraints is the negative legacy of slavery and plantation agriculture, which continues to exert its effect on public perceptions and policies towards agriculture.

During the period 1983 to 1998, agriculture as percent of total GDP declined from 4.82 to 3.56. This translates to a slight increase in actual dollar value. Fisheries makes the greatest contribution to the sector (49.8%) and indicates the importance of maintaining productivity in coastal waters. Barbuda depends heavily on this activity and lobster exports, continue to make a major contribution.

Although some small amount of cotton production continues (< 300 acres), the major crop production activities are in vegetables and food crops and lesser quantities of vine and tree fruit. The local Antigua Black pineapple is one of the major fruit crops produced.

Farmers have taken advantage of irrigation and other technologies and a small core with medium sized farms (5 to 15 hectares) have developed highly efficient, mechanized production technologies and have demonstrated the potential to produce high quality produce competitively. However, lack of continuous water supplies and difficulties with gluts caused by imported produce have deterred many from

investing further in needed infrastructure or marketing systems. Many farm on land rented from the Government with little security of tenure, further reducing willingness to invest.

The dry climate of Antigua and Barbuda is well suited to livestock production and the grassland areas support considerable populations of cattle and small ruminants. However, production remains a part time hobby for many livestock owners, who rely on waste land as pasture. Production practices are basically impossible to improve under these conditions and even for those with land, livestock production generally remains a low-input/low-output enterprise, subject to the vagaries of the weather.

The future development of agriculture and fisheries will have an important influence on the management needs of the watersheds and coastal zones. A sustained effort to reduce the level of food imports, particularly in the tourism sector, probably offers the best option for agricultural development in the near future. Attempts to increase the linkages between the tourism sector and agriculture are under active discussion, but the effort needs to be continued and intensified. A development focus in this area would be likely to result in more intensive production in the better soils close to irrigation water, which may have implications for water resources with respect to both quantity and quality. Other constraints such as land tenure will also need to be addressed.

Opportunities for successful export based production appear limited due to the problems of high labour costs and small scales of production, which reduce competitiveness. However, some opportunities for production of specialty products such as sea island cotton may have potential, especially if a proportion of the production can be processed into quality products for the up-market tourist visitor with a high value added. The increasing interest in natural materials and products in developed countries may provide some potential here. These types of development could utilize existing forest and scrubland as the source of raw materials, providing incentives for better conservation and management of watershed areas.

Inshore fisheries resources are already heavily exploited and need to be carefully conserved if serious depletion is to be avoided. Developments in this sector are focusing on the exploitation of resources further offshore, but this requires better-trained fishermen and a greater investment in boats and handling equipment.

There are signs that agriculture and the natural resources on which it depends are beginning to be recognized as significant components of the tourism experience which Antigua has to offer. Eco-tourism has begun to see significant developments as cruise ship visitors, in particular, demand more things to do during their brief stopovers and this trend is likely to intensify. Very recently there have been some developments in the area of agro-tourism, which may also have some potential.

2. Water Resources and Coastal Zone Management Issues

2.1. Watershed Management

2.1.1. Agriculture and Forestry

Antigua's history has had a profound effect on the present state of its watersheds and biodiversity. The soils and relatively gentle topography of Antigua lent themselves to cultivation and contributed to the almost total deforestation of the island to plant sugarcane in the 1700s. Due to cultivation of much unsuitable land, extensive erosion and soil degradation took place, especially in upper watershed areas. However, much arable land of reasonable productivity still remains, though this is coming under increasing competition from housing, industrial and other urban development, especially around St. John's and major tourism development areas. Antigua currently possesses 2200 ha of crop land. A further 10,700 ha are used for grazing of cattle and small ruminants, though the area is difficult to define as the grazing is mostly "unofficial" and temporary. Woodland occupies 9,600 ha. Another study of forest resources carried out in 1983 estimated the areas of woodland and scrub vegetation at 5,600 ha and 10,000 ha respectively (DFS 1984), indicating the variation in areas depending on classification. Much of the upper watershed areas not in scrub or woodland are used for rough grazing. These lands are frequently burnt to provide fresh grass for livestock to eat, but this is uncontrolled and frequently leads to further destruction of the adjoining forest and scrub vegetation.

Antigua's agriculture is mainly confined to production of food crops, fruit and vegetables for the local market. The only significant export crop is sea-island cotton for the Japanese market. Local markets are necessarily small and easily saturated leading to a cycles of gluts and scarcities. This is compounded by the lack of adequate water for irrigation, forcing many farmers to produce only when rainfall is adequate. Soils are quite fertile, many with good texture and gentle slopes, making mechanization quite feasible. In fact, there are a number of very competent farmers who have applied quite advanced levels of technology, including mechanized seeding, use of drip irrigation and selective herbicides.

As mentioned above, Antigua's original forest cover was almost completely removed for sugarcane production and much of the original soil cover lost. Some re-growth of secondary forest has taken place especially in the wetter and least accessible areas, but Antigua remains depleted in true forest cover. There has only been one attempt at reforestation on any significant scale. This was at Wallings and involved the planting of approximately 5 hectares of trees in 1912 to protect the watersheds supplying water to the Wallings reservoir. A detailed inventory (Beard, 1949) identified 47 species of trees in a half acre (2000 m²) quadrant of the Wallings forest. A similar inventory at Brecknocks found only 14 species.

Forest areas are, none the less, important sources of raw materials for several industries. Charcoal making continues to use significant quantities of wood from bush and trees, unfortunately, too frequently, quality timber trees are used for charcoal making. Extraction of wattle for fishpot making is also a major use of forest products. After the loss of thousands of fishpots during hurricane Luis, demand for wattle was exceeding supply. Honey bees also make considerable use of flowering plants in the forest as source of pollen and nectar. Medicinal plants, used in traditional medicine and increasingly in modern preparations are also found primarily in forest areas.

Increasing attention has been paid in recent years to the forest for recreation and as an eco-tourism resource. The growth in use of the Wallings dam and trail system by individual visitors, hikers and tour groups from cruise ships is evidence of the growing demand for such experiences and evidence that there are several levels of eco-tourism not all of which are dependent on virgin rain forest to attract the casual visitor.

The forest and shrub covered areas are also, of course, vital to the protection of the major watersheds in the areas of heaviest precipitation. This will be dealt with further in Section 2.1.3.

2.1.2. Biodiversity and Wildlife

The biodiversity of Antigua and Barbuda suffered a similar fate along with the forest cover. Destruction of habitat during early colonial times was severe and extensive in a country where, it has been estimated, that 92% of the land area was eventually cleared for sugarcane cultivation.

Despite these losses, much of considerable interest and significance remains and should be conserved. Island ecosystems are typically rich breeding grounds for endemism and high levels of diversity on an area basis.

Vegetation

There have been several attempts to classify the current vegetation of Antigua and Barbuda, the most recent by Lindsay and Horwith as part of the Convention on Biodiversity enabling activities (Lindsay and Horwith, 1997a). Their study identified 54 Plant Alliances and Associations, belonging to 5 vegetative classes. In an associated study, Lindsay and Horwith (1997b) listed 1,158 species of higher plants (149 families), including 45 species of ferns and fern allies; 4 species of gymnosperms (3 families) and 1,109 species of flowering plants (141 families) which are known to occur in Antigua, Barbuda or Redonda. Twenty two species are identified as endemic to the Lesser Antilles, including one, which may be endemic to Barbuda. One hundred and ninety seven species of flowering plants and 24 species of ferns were considered rare, and either Endangered or Vulnerable and therefore meriting special conservation concern. No information was provided on mosses, liverworts or fungi.

Of importance to watershed management is the quality of vegetative cover on the upper watershed areas where slopes are steepest and rainfall erosivity highest. No specific study of this aspect of vegetation has been undertaken, but qualitative observations would suggest that the protection of many upper watershed areas is of poor quality, especially in areas where Citronella grass is the dominant vegetation.

Fish

The fresh water fish of the Lesser Antilles have not been extensively studied, but 5 native species are known for these islands. A list of marine fish that occur specifically in the waters of Antigua-Barbuda-Redonda does not exist, but fish guides for the wider Caribbean list some 400 species.

Amphibians and Reptiles

Only two amphibians are known for Antigua; a tree frog and the marine toad. Twenty species of reptiles are listed, four being now extinct. These include three species of gecko, three *Anolis* lizards, the green lizard endemic to Antigua, a lizard endemic to Redonda and the ground lizard common to Barbuda but found only in parts of Antigua. There is also a blind snake (*Typhlops* sp.) and the Antigua Racer snake (*Alsophis antiguae*) endemic to Antigua and amongst the rarest snakes in the world. Three marine turtles are found in Antigua and Barbuda's waters - Hawksbill, Green and Leatherback. The Hawksbill

is known to nest on several beaches and studies of the population nesting at Long Island have been carried out for over 15 years.

Birds

One hundred and eighty two species of birds are recorded for Antigua and Barbuda, two thirds of which are migratory. Twenty of these species are sub-regional endemics. Two are single island endemics. The wetlands and offshore islands are of special importance to many species of birds as they are important feeding grounds and nesting sites.

Mammals

Bats are the only native terrestrial mammal in the country and seven species of bats are found in both Antigua and Barbuda. Agouti, Fallow Deer, Indian mongoose, rabbits and rats were all introduced.

Marine mammals are represented by seven species of whales and dolphins. One whale, the Humpback, is relatively common to waters around the islands. Several species of dolphins are also recorded.

Invertebrates

Knowledge of the invertebrate fauna is not well recorded. Species listings are very incomplete and largely restricted to agricultural pests and some beneficial insects. Studies of invertebrate fauna associated with freshwater ecosystems are notably lacking.

2.1.3. Land Use and Ownership

The Agricultural Census carried out in 1985 identified land utilization/vegetation in Antigua as shown in Table 2.1. (OAS, 1990) This shows that there were some 3183 ha of crop land and improved pasture; 9767 ha of rough grazing and mixed scrub/rough grazing; and a further 9569 ha of woodland. Swamps, mangroves and beach sand occupied 876 ha. Urban areas, industrial sites, tourism related uses (hotels, golf courses, historical sites, etc.) and airports occupied a total of 3225 ha.

Since the time this survey was done, there has been considerable expansion in the areas of some rural settlements, which then occupied only 763 ha. This figure could well have doubled with the housing construction programmes of the last ten years.

In Barbuda, less than 1 per cent of the land area is occupied by human settlement and related uses (109 ha). Dry forest areas occupied 7,900 ha and swamps and mangroves a further 3,729 ha., most of which is contributed by the Codrington lagoon.

Table 2.1 Land Use in Antigua, 1985

Category	Area (ha.)	Percent
Agriculture - Crop	2,226	8.5
Agriculture - Livestock		
Improved pasture	957	3.6
Rough grazing	6,942	26.4
Mixed scrub/rough grazing	2,825	10.8
Woodland		
Volcanic areas	6,147	23.4
Limestone areas	3,422	13.0
Rural areas	763	2.9
Urban areas	1,946	7.4
Industrial areas	154	0.5
Hotels, Golf courses, Other tourism related	458	1.7
Recreational and historical areas	289	1.1
Airports and Military installations	378	1.4
Dams and reservoirs	257	1.0
Swamps, mangroves and beach sand	876	3.3

Source: OAS 1990, (quoted in CEP 1991)

2.1.4. Watersheds

A watershed is a topographically defined area having a common drainage system. Watersheds are used as fundamental units for assessing hydrological budgets and processes such as erosion and to provide for land use planning and management.

Antigua

Antigua's 86 watersheds recognised by the Halcrow study (Halcrow 1977) were grouped by McMillan (1985) into are 13 larger watershed groups. These are depicted in Figure 2.1a. The two largest watersheds (1 Potworks, and 2 Big Creek) drain the northern slopes of the south west volcanic region and the main parts of the Central Plain to the east and west respectively. Fitches Creek drains into North Sound. Christian Valley, Parham and Bethesda are also important watershed groups. These six watersheds occupy 43 percent of the land area and contain 80 percent of the groundwater supplies and

90 percent of surface water storage. Within these watersheds are found 50 percent of the island's forest land, 90 percent of its crop production, 60 percent of livestock production and 70 percent of the population (Fernandez 1990). Details of these six major watersheds are provided in Table 2.2

Table 2.2 Features of the six major watersheds in Antigua

Watershed	No.	Area (ha)	Existing Storage (acre feet)		Groundwater Yield (m ³ /yr)
			Agriculture	Municipa l	
Creekside	2	4,000	200.4	278	390,000
Potworks	1	3,160	30.6	4,010	220,000
Christian Valley	4-11	1,780	9.2	166	610,000
Parham	63-66	1,472	33.4		
Fitches Creek	3	1,040	334.5		
Bethesda	47-53	120	540.0		
Total		11,572	1,148	4,454	1,220,000

Source: Fernandez et al (1999)

It can be seen from Figure 2.1a, that all the watersheds are quite short, the largest being not more than 11 km in length. The two largest have areas of 4000 ha and 3,160 ha respectively. Considerable portions of many watersheds are close to the coast and salt water intrusion is a factor in the quality of some surface storage and ground water supplies in many aquifers.

Vegetative coverage of these watersheds is very variable. The upper catchments may have considerable forest cover mixed with scrub and brush. The Creekside watershed in particular has considerable areas where citronella grass (*Cymbopogon citratus*) is the dominant cover. This poses specific problems which are discussed later (Section 2.1.7.3) On the lower slopes, rough grazing and pastures as well as crop production are important land uses.

Barbuda

Barbuda has been divided into 10 watersheds as shown in Figure 2.1b. The relatively flat nature of the topography and permeable nature of the soils in Barbuda make surface runoff minimal and surface catchments impractical. Surface cover is generally evergreen woodland.

2.1.5. Water Resources

In Antigua, fresh water resources are found in three forms: surface storage, groundwater sources and domestic catchment in cisterns and storage containers. There are no permanent streams or rivers in Antigua or Barbuda. Stream flow in the various ghauts and valley bottoms is short lived and occurs during, and for short periods after, rainfall events. After heavy or prolonged rainfall, some sections of

Figure 2.1a Location of major watersheds in Antigua

Figure 2.1b. Location of watersheds in Barbuda

See file: (figure 2_1ab.pdf)

the larger streams may flow for periods of a few months. All the major catchments are dammed at several points to retain streamflow.

In addition to these freshwater resources, seawater is being increasingly used to provide water for domestic and agricultural use through desalination.

2.1.5.1. *Surface Storage*

Table 2.3 provides details of the surface storage capacity of the thirteen watersheds and some additional surface storage potential, which has been proposed.

Table 2.3 Antigua's surface storage capacity estimates for existing and proposed agricultural and municipal supplies (acre-feet) (1 acre foot = 1233 m³)

Watershed No.	Agriculture Storage		Municipal Storage	
	Existing	Proposed	Existing	Proposed
1	30.6	82.9	4,010	-
2	200.4	202.2	278	4,120
3	334.5	18.2	-	-
4-11	9.2	25.2	166	160
12-20	2	-	50	140
21-26	-	-	-	80
27-46	5.2	10.7	-	-
47-53	570.4	32.5	-	-
54-62	19.2	33.6	-	-
63-66	33.4	59.1	-	-
67-77	38.4	16.3	-	-
78-84	2.2	-	-	-
85-86	2.5	2.2	-	-
Totals	1248.0	482.9	4,504	4,500

- Notes: (1) Does not include Red Hill (46 AF) and Picadilly (c. 2 AF).
 (2) Includes Bethesda (540 AF), which has been converted to municipal use during droughts
 (3) Does not include Langfords (99 AF)
 (4) Potworks (3,700 AF) + Collins (310 AF)
 (5) Creekside (2900 AF) + Body Ponds (1200 AF)

Source: McMillan (1985)

Antigua has 10 medium to small reservoirs and some 550 ponds and earth dams with a total designed capacity of approximately 5,700 acre feet. Of this total capacity, 4,500 acre feet is utilized for municipal water supplies. In 2000, the volume of surface water supplied to the domestic distribution system was 1.27 M cubic metres (336 Mgals), or 3475 m³/day (0.92 Mgal/day).

Most surface storage, including the largest reservoir, Potworks, is shallow and exposed to the prevailing trade winds. The constant wind run and high temperatures result in high rates of evaporative loss from these storage systems, especially the mini-dams and ponds. Many of these will dry up during the dry season of an average year and do not provide reliable storage for agricultural use. There are no permanent rivers or streams in Antigua and recharge of ponds and reservoirs takes place during rainfall events. Depending on the depth of drying out of the soils in the watersheds, considerable rainfall is often required before runoff and significant recharge takes place. Total rainfall for a period may not therefore give an accurate forecast of storage recharge. Amount and intensity information on each event is needed to better predict runoff.

The majority of storage is located in the Central Plain where topography and soil conditions are more favourable. The limestone zone is generally unsuitable for storage because of very permeable subsoils. Barbuda has very little potential for surface storage due to the flat topography and permeable nature of the main soils.

2.1.5.2. Groundwater Supplies

In Antigua, suitable groundwater storage is found primarily in the sandy deposits underlying the valleys bordering the volcanic region of the south-west. Currently, water is pumped from some 50 active wells. The higher yielding aquifers are found in the Bendals Valley, Bolans and Collins areas. Most wells have been drilled to depths of 24 to 30 metres (80 - 100 ft.). Production of the major well fields for 2000 is given below:

Well Field	Annual Production for 2000 (Cubic metres/yr.)
Bendals	251,000
Christian Valley	40,000
Claremont Cades Bay	74,000
Collins Bristol Springs	266,000
Follies	29,000

(Source: V. Yearwood, 2000)

In several areas, ground water is of varying salinity and usually this problem is worse closer to the coastline where fresh water overlies salt water lenses connected to the sea.

Some wells have been abandoned or temporarily put out of use, due to salt water intrusion. This occurs particularly during periods of drought when water resources are severely stretched and wells are over pumped. Since 1989, there have been at least three periods when surface water resources were essentially depleted. During such droughts, Potworks reservoir has been dry for periods of several months. At these times demand on ground water resources reaches unsustainable levels, even with desalination plants at full production.

In Barbuda, the primary source of fresh water is from shallow aquifers that underlie the 650 hectares of sands in the Palmetto Point area. Elsewhere ground water is saline and unsuitable even for agriculture. Water development potential is reported to be 53 acre feet per annum (AFA) although recharge rates indicate considerably higher potential.

2.1.5.3. Domestic Catchments

New domestic buildings are required by the Development Control Authority to include in their construction plans, permanent water storage according to roof area. There are no reliable estimates of the rainwater stored this way, but it is believed that it makes a significant contribution to the domestic supply in both Antigua and Barbuda. Many householders not connected to pipe-borne supply also collect rainwater in tanks or drums.

2.1.5.4. Desalinated Water

In recent years, desalination capacity has been invested in, to supplement the supply from natural sources. This was a response to the periodic drought crises such as that in 1983/84, when fresh water had to be barged in from neighbouring islands.

Currently there are 2 municipal desalination plants located at Crabbs, on the northeast coast and another is planned for Barbuda. The larger thermal plant at Crabbs has a capacity of 7575 m³/day (2 MG/D). The second plant, commissioned in 1993 is a reverse osmosis plant with a capacity of 3030 m³/day (0.8 MG/D). In addition to these municipal facilities, several coastal hotels and manufacturing plants have invested in their own desalination plants to insure a dependable supply.

The result of these developments is a much more reliable domestic supply, produced at a high cost. Average daily supply for 2000, from all sources, was approximately 15,500 m³/day, to which desalinated water contributed 10,200 m³/day; surface supplies, 3,500 m³/day and groundwater, 1,800 m³/day (V. Yearwood, 2001). There were also small contributions from household catchments (cisterns) and private ponds for agriculture. Actual proportions will vary from year to year, due primarily to fluctuation of the surface supplies as a result of rainfall.

Water supplies for agriculture have seen no major developments, except for some mini-dam construction and some vegetable farmers, where they are suitably located near to the domestic supply and who can afford to use the domestic supply for their irrigation needs.

Costs of producing potable water for distribution from the various sources are given in Table 2.4 below. These compare with a consumer price of EC\$ 21/1000gals (US\$ 2.05/m³)

Table 2.4. Approximate water production costs

Water Source	Cost (US\$/m ³)	Cost (EC\$/1000 gal)
Ground	2.50	25.57
Surface	3.00	30.68
Desalination	4.70	48.07

Source: Fernandez et al (1999)

The table indicates the high cost for desalinated water and suggests that it is not practical to rely on such sources for agricultural use, except in very intensive production systems.

The difference between water production costs and water revenues shows that piped water is highly subsidized. The existing differentiated tariff structure means that certain consumer groups such as non-domestic users, have to pay a higher price.

2.1.6. Improving Management of Water Resources

Water is a critical resource in a semi-arid country such as Antigua and Barbuda. Careful planning and development; equitable distribution of this resource among the various sectors of the economy; and conscious efforts at conservation and reuse at all levels of the economy, would appear to be the key elements of a sustainable water management policy.

2.1.6.1. *Municipal Water*

As indicated in Section 2.1.5.4., municipal demand for potable water currently stands at approximately 15,500 m³/day. This demand is met from desalination (66%), surface reservoirs (22%) and ground water (12%). During normal rainfall years, the situation is reasonably secure, with even some water left over to supply agricultural needs. However, during the droughts which Antigua experiences on a frequent but unpredictable basis, municipal demand exceeds supply as surface sources become exhausted. At this point, ground water resources are often over-exploited and salt water intrusion may occur.

During wetter than normal years, considerable quantities of fresh water are lost to the sea as reservoirs and mini-dams over flow. While Antigua does not have ideal conditions for abundant water storage, additional possibilities for surface storage have been proposed by several professional studies (e.g. McMillan, 1985) but have not been exploited. A planning time frame that looks 25 or 50 years ahead would suggest that suitable sites be identified and set aside now, before unsuitable development takes place. The view that we should increase our reliance on desalination to provide the additional supplies required is attractive from a high technology standpoint, but if energy costs are likely to increase more rapidly in the long run, this option becomes less attractive, especially as it will virtually exclude agriculture from obtaining a share of this vital resource.

2.1.6.2. *Water for Agriculture*

Since Antigua's annual average evapotranspiration is significantly higher than the annual average rainfall, (Section 2.1) supplemental irrigation is necessary for sustained yields and even moderate levels of production, especially in drought years. These can be expected at least one year in five and in the last decade have occurred three years in ten. With global warming expected to increase the extremes of weather experienced, irrigation is likely to become even more critical.

Another factor increasing the need for greater dependence on irrigated production is the increasing competition that farmers are going to face with the reduction in protective tariffs and other structures mandated by WTO agreements, which will begin to take effect in the next two to three years. Similarly, current attempts by the Ministry of Agriculture to secure a greater market linkage with the tourist sector, by increasing sales of vegetable and fruit produce to hotels and even cruise ships, will require a steady and reliable supply of produce to these markets from local producers. This will be impossible to achieve with rainfed production systems. Antigua's rainfall reliability is such, that even in so called wet season months, short, dry periods frequently occur that are sufficient to seriously affect vegetable production, especially if occurring at critical periods of growth.

At the moment, irrigation water is provided by a mixture of potable water taken from the government supply, surface supplies from reservoirs, mini-dams and ponds and in a few cases from private wells.

Currently, distribution is restricted to those farms in easy distance of surface or municipal supplies. When water is restricted, municipal needs are paramount and agriculture suffers. No reliable figures are available for the current consumption of water for irrigation or the proportion obtained from municipal sources. However, if crop production were increased to meet the current levels of importation of fresh vegetables, salad crops and vine fruit, approximately 1.2 Mm³/yr (1000 ac ft/yr) of water would be required. At present, only a small percentage of farmers have access to water year round and it is estimated that approximately, some 40% of crop farmers have access to some irrigation.

The Ministry of Agriculture, through its Soil and Water Conservation Division has had a programme of encouraging farmers to invest in irrigation and has assisted with the construction of mini-dams and some larger ponds in key production areas. Use of drip irrigation has been promoted and many farmers have adopted this technology to varying degrees. Some larger farmers have invested heavily in dams and irrigation equipment. However, progress has been constrained due to damage to dam structures in the recent hurricanes. Also, because there is no clear policy regarding allocation of water resources, some farmers have suffered, when their source of water has been 'redirected' to municipal supplies during severe droughts, a time when their own production is seriously threatened. Improvements to the supply of water available for irrigation are therefore vital to any programme of agricultural development.

2.1.6.3. *Managing Water Resources*

There is obviously a need for a clear and fair policy for water allocation to municipal uses and agriculture to alleviate the problems discussed above. While water resources remain the sole prerogative of the APUA, it is difficult to see how this will come about, as APUA has no official or legal mandate to supply water for agriculture (See Section 3.4.2).

It would seem desirable to vest these powers in a body, such as a Water Resources Board, that would be representative of all water user interests. The Board should be responsible for planning development and allocation of water resources, as suggested ten years ago (Henry, 1990). The Board would also need to develop a policy to significantly improve water conservation efforts, by reducing use and encouraging reuse of grey water and treated sewage effluent for irrigation and grounds maintenance. Some hotels have shown that this is quite practicable and may well be demanded by tourists in the future.

As demands for water increase and worsening climatic threats to water resources are predicted, it is doubly important that these resources be effectively managed.

2.1.7. Improving Management of Watersheds

At the moment, it is quite true to say that no management of the country's watersheds is practiced. Minimal activities such as cleaning of sediment from ponds and reservoirs and some ghauts close to these installations is carried out, but apart from this, watersheds are left to function without official interference. The result of this is that problems of misuse and abuse go unresolved. The Forestry Division needs the resources and manpower to manage a vigorous watershed management programme in the key watershed areas, so as to improve the ability of these watersheds to produce more water for surface storage and ground water recharge.

2.1.7.1. *Maximizing water retention*

Since surface storage is quite limited and subject to evaporative losses, sub-surface retention within the watershed by increasing percolation should increase retention and prolong stream flow. Where vegetative cover is reduced through clearing, burning or overgrazing, runoff is accelerated and retention reduced. A multi-story vegetative canopy and humus covered topsoil are thus required to maximize retention. The steeper the slope and more intense the rainfall, the more this applies.

2.1.7.2. *Erosion management*

Loss of topsoil through sheet erosion is often a slow process, which is not very visible and is frequently ignored until most topsoil has been lost and restoration is either impossible or very costly. As mentioned in the previous Section, topsoil retention aids moisture retention through facilitating deep percolation, helps maintain vegetative cover and reduces siltation of downstream storage and wash of sediment into the coastal waters where coral and other marine life may be affected. Keeping the soil covered with vegetation is paramount in any strategy to reduce sheet erosion losses.

Landslides and gully formation are usually significant when topsoil has already been largely lost. However, these processes occur where runoff is concentrated in ghaunts or natural drainage ways on steeper slopes. Vegetation is the key to minimizing their development. As Hurricane Lenny showed, however, even on vegetated slopes, 500 mm of rainfall in 24 hours can cause great destruction of even vegetated slopes.

2.1.7.3. *Grazing and Land Degradation issues*

Antigua has a large population of cattle and small ruminants including goats. At least half the population of livestock is owned by farmers who have no land. Animals, therefore, are grazed on waste and otherwise unoccupied land, sometimes on steep lands in the upper areas of the watersheds. Normal grazing of the grass covered areas found near the summits of the South west mountain block is generally not detrimental to the vegetative cover, except in localized areas where livestock gather. Goats are a special problem, however, as they eat a much wider range of shrubby vegetation and tree seedlings and can denude the understory, removing tree seedlings and limiting species diversity. Serious degradation of watershed vegetative cover exists in a number of areas of both private and government lands.

Clearing of land for agriculture is generally more a problem on the lower slopes of most watersheds where erosion risks are less. However, some practices affect the upper watershed areas. Clearing land by burning off vegetative cover prior to cultivation is a common practice. Although burning is supposed to be controlled by the issuing of permits issued by the Fire Department, few adhere to this practice and it is not enforced. The legislation is archaic and takes no account of practices designed to limit danger of fire spread, such as burning during the cool part of the day. As a result of this situation, many fires are unsupervised and get out of control burning large tracts of hillside and removing vegetative cover.

A particular problem exists in the Potworks and Creekside watersheds, where there are large areas of citronella grass. (See Section 2.1.4) This grass was planted to control erosion in the Body Ponds area about 100 years ago. It is a very sturdy grass, will grow on very denuded soils and generates considerable biomass in a short time. However, it is particularly prone to fire, to which it is also very well adapted. The dead leaves and dried flower stalks burn very easily and rapidly when ignited. Fires spread rapidly in this grass, but the grass survives and re-sprouts in a short while. However, other vegetation is killed or greatly set back by these fires which in some areas are set every few months. Forest and bush at the edges of the grass are being slowly burnt back, and the grass is expanding in area each year. At the moment several hundred acres of the citronella grass exist. Although it provides some

soil cover, it is not effective in controlling sheet erosion because of the bunch habit of the grass and the frequent fires which are removing valuable nutrients and baring the soil to rain splash after each fire. Citronella grass areas are extremely poor in species composition and as a biodiversity habitat. Unless the problem of citronella grass is tackled soon, the most important watershed areas will be devoid of tree and bush cover in 25 to 30 years as the grass takes over.

2.1.7.4. *Biodiversity conservation*

An important benefit of healthy watersheds covered with a variety of vegetation is the varied habitat this provides for a range of flora and fauna. Besides serving to stabilize these ecosystems, the biodiversity is a source of medicinal plants and others of economic significance for their use as pesticides, natural dyes and other such uses. A rich biodiversity can also be a valuable resource in developing eco-tourism potential as discussed below.

2.1.7.5. *Tourism and Recreational use*

An analysis of the development of tourism in the last few years will show that tourism needs are changing and that the attractions of "sun, sand and sea" for which the Caribbean is rightly famous, are not enough. Our visitors are looking for more and a growing interest in nature and the environment, as well as greater knowledge of tropical forests and marine life are creating tourists who want to see as much as possible of the natural history of the places they visit. It is no surprise then, that eco-tourism has seen a significant expansion in the last 10 years, moreover visitors to places like Antigua, not especially famous for its flora and fauna, are interested to see what the country has to offer around its reefs and shores and in its forests.

Off-road tours, group hikes and even treasure hunt style excursions in natural areas are rapidly gaining favour with the cruise ship passenger and group tourist. The popularity of the Wallings trail system with tourist groups in the last few years is evidence of this growing trend. While these developments may assist in making the maintenance of natural areas a higher priority, they also point to the need to manage eco-tourism properly and to determine levels of usage that are sustainable. Heavy traffic into sensitive areas, whether the Wallings forest or the Codrington Lagoon may result in physical or biological degradation of the site. Simple measures such as walkways, hides and notices about expected behaviour can assist considerably, but in sensitive areas, wardens and restrictions on numbers or access may be required. Waste management is another factor that needs to be planned for.

2.1.7.6. *Carrying capacities*

As mentioned above, all sites with a biological component have a carrying capacity that, if exceeded, will lead to the deterioration of the biological resource. Some sites are more fragile and sensitive than others. Some sites lend themselves to practical and inexpensive measures that can go a long way to minimising damage and thereby increasing carrying capacities. Some of these were mentioned in the last section. Buoy moorings for water craft visiting reef sites to fish or observe the wildlife are another example, since anchors can do significant damage to living coral. At the moment, these concerns are shared by only a few persons within the environment related institutions such as Environment, Fisheries, Forestry and some of the NGOs.

2.1.7.7. *Balancing multiple uses*

The need to find a more equitable balance between competing needs of the Domestic sector and Agriculture for scarce water resources has already been discussed at some length. Similar conflicts exist between the tourism development agencies and those dependent either directly or indirectly on mangrove wetlands, for their livelihood. Wetlands are frequently near to attractive beach systems and are sought after by developers for siting marinas, hotels and golf courses. Unfortunately, the price of wetlands land usually does not reflect its importance and value to the protection of fisheries and coastal erosion, so is often cheap as real estate. How can the true and long term value of wetlands be more accurately and meaningfully accounted for? This will be difficult until there is a better general understanding of the wetland's role in coastal protection and health. Perhaps the educational activities of the various environmental Conventions referred to earlier can help in this regard. Certainly novel ways need to be found to attach value to environmental assets, so that a better balanced assessment of cost and benefits can be made.

2.1.7.8. *Revenue generation*

At present, there is little scope for generation of revenue to assist in the management and development of watershed or forest areas. However, with the development of greater opportunities for eco-tourism, the possibilities for charging user fees has improved. Such practices need to be part of the development of park and forest reserves, where facilities are provided and use can be regulated.

The Forestry Division has recently begun to provide trail guides in the Wallings area as a regular service to tour companies offering hiking tours to cruise ship visitors. This type of service could, no doubt, be expanded in the future. Consideration should also be given to entrance fees for tour companies for use of facilities such as Wallings, which need maintenance and development. The experiences of the Nation Park Authority in this regard may be helpful in determining the right approach.

The legal implications of this approach need to be explored as well as measures to reduce any deterrent to the local population to use such facilities. A better equipped Forestry Division may wish to consider granting licences or permits for extraction of forest produce, which could also assist in revenue generation.

2.2. Management of Coastal and Marine Resources

2.2.1. Coastal Habitats and Ecosystems

2.2.1.1. Mangroves

Antigua and Barbuda's wetlands and the associated mangrove woodlands, are vital components in the maintenance of a healthy beach and reef system. Mangrove wetlands provide the transition for freshwater exiting from the watersheds and its entry to the sea. The four mangrove species found in Antigua and Barbuda are the Red (*Rhizophora mangle*), Black (*Avicennia germinans*), White (*Laguncularia racemosa*) and Button (*Conocarpus erectus*). These four species inhabit different parts of the wetland habitat and their roots and associated plants retard the flow of silt-laden freshwater, allowing the silt time to be deposited in the swamp, rather than being washed out into the sea, where it will settle on coral formations. Coral is particularly sensitive to silt damage and turbid waters support very much poorer reef communities.

The silt load also brings with it considerable nutrients which feed the mangrove system and make it biologically very productive. In fact, healthy mangrove wetlands are among the most productive ecosystems known. This is why mangroves provide such an important habitat for juvenile fish such as mullet, snapper and mojarras, as well as other predatory fish species

2.2.1.2. Sea grass

There are extensive areas of sea grass beds in the shallow waters around the coasts of Antigua and Barbuda. Sea grass communities are generally found in waters up to 20 metres deep. Species lists for the coastal flora and fauna are not available, but there are three main sea grass species found in the islands' shallow waters. These are turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*) and shoal grass (*Halodule wrightii*). Calcareous algae such as *Halimeda* sp. which also are found among the sea grasses, are believed to be the major source of the white sand found on Antigua and Barbuda's beaches. These species and other epiphytes provide important feeding grounds, shelter and breeding areas for juvenile fish, Queen conch, spiny lobster and other marine organisms.

Sea grass beds are important in helping to stabilize loose sand thereby retarding coastal erosion. Also, it is not often recognised that calcareous algae, which are found among the sea grass, are important sources of the white sand, which makes our beaches so attractive (Multer, 1988).

2.2.1.3. Beaches and Sand Bars

The beaches of Antigua and Barbuda are perhaps the most valuable physical asset the country possesses. There is no doubt that they are the major attraction for many of the tourists whose visits fuel the economy. They are also a major barrier to the constant force of coastal erosion, which eats away at our land base. White sand beaches are found in almost all parts of the coast line of Antigua and are especially well developed on the west coast. In Barbuda, wide sandy beaches stretch uninterrupted for several miles on the west coast. Considering the low lying nature of the inshore area, this measure of protection is most important.

With growing concern about the effects of increased hurricane damage on these defenses and threats from sea level rise associated with global warming, the health and maintenance of our beach systems should be a top priority. Instead, the last decade has seen an escalation of practices which undermine the very existence of our beach system.

There has been extensive mining of many beaches, especially those on the west coast of Antigua and the sand deposits of Barbuda. In Barbuda, removal of sand deposits in the Palmetto Sands area has raised the effective water table by several feet and exposed part of the shallow freshwater aquifer to drying out.

In the Pearn's area of Antigua, several smaller less accessible beaches have become rocky shores. At other beaches, mining combined with storm damage, has caused excessive rates of erosion, fallen trees marking the inward march of the highwater mark.

2.2.1.4. Coral Reefs

Coral reefs are a vital habitat for many of the inshore fisheries resources as well as providing habitat for life stages of many pelagic fish and other marine organisms such as the sea turtles. Antigua and Barbuda is fortunate in possessing extensive systems of off shore reefs. These were described in Section 1.3.1.

Studies have been made of the reef systems and the state of their health, in the last few years. Some reports have suggested that there has been significant deterioration and that some reefs are showing considerable signs of stress (CIDA 1988). Sediment stress has been implicated by some authors for the absence of elkhorn and star corals in some reefs on the west coast close to dredged areas. Eutrophication and pollution from sewage discharge are also frequently cited as concerns, despite some improvement in the standards of maintenance by hotels of their sewage treatment plants.

2.2.2. Exploitation and Use of Coastal Zone Resources

2.2.2.1. Fishing

The fishing industry in Antigua and Barbuda produces revenues of approximately EC\$ 30M, which is nearly twice that of crop production activities and provides a livelihood for over 600 fisherfolk and their families. For the most part, fishing is carried out close to shore and fish traps are the dominant method of harvesting. The main fish caught include the shallow and deeper reef fish as well as Spiny lobster and conch. Investment is small and technology is limited. Services for fisherfolk are provided by the Antigua Fisheries Ltd, a statutory body set up to provide cold storage facilities, ice and other inputs, etc. for the fishing community.

The Fisheries Division of the Ministry of Agriculture, Lands and Fisheries, is expected to provide the technical resources for management and development of the Fisheries Sector. The Division, comprising nine professional staff members, provides monitoring of catch and the status of fish populations as well as training of fishermen and regulation of fishing activities. The Division is also responsible for the management of the three marine reserves now in existence. Lacking a single vessel, the Division relies heavily on the Coast Guard, with whom it has a close working relationship, to provide sea transportation to carry out its various responsibilities.

The Division is concerned about declining catch figures and would like to see fishermen trained and with the financial resources to make greater use of the further off shore fishing grounds, in order to take pressure off the near shore areas and allow some rebuilding of fish stocks.

There is also significant sport fishing activity, which concentrates primarily on the larger pelagic fish such as dolphinfish and marlin. The Sport Fishing Association organises regular tournaments.

2.2.2.2. *Sand Mining*

Pressure from the construction industry and the lack of suitable alternative sources of building sand, has resulted in extensive mining of sand from a number of beaches around the island, despite legal restrictions designed to regulate sand removal. Some beaches have been so badly mined that they are now no longer beaches but rocky shores. In other places, the removal of sand has threatened to allow the sea to breach the natural shore line. Given the threats to shorelines from hurricanes and storm generated swells and surges experienced in the last decade, protection of the beaches from damage by sand removal is a pressing concern.

Control of beach sand removal is vested in the Public Works Department, which is empowered to issue permits. However, it has no control over how the removal is carried out and is not able to regulate the quantities removed. Legal difficulties regarding definitions of beach and other problems remain to be resolved

Despite many statements by government authorities, that sand mining needs to be controlled, little seems likely to change until alternative sources of sand for construction are available.

2.2.2.3. *Recreational and Tourism Related*

Antigua and Barbuda's beaches have been, perhaps, the major component in the tourism product which Antigua and Barbuda has to offer the visitor. The abundant seagrass beds and nearshore coral reefs as well as the shallow slope of the coastal shelf in many parts of the coast have provided the country with many safe, beautiful white sand beaches. However, hotel development on beach fronts without adequate setbacks has resulted in beach erosion, leading to a cycle of demand for protective measures which are likely to compound the problem in the long term.

Tourism related development has had a significant impact on other coastal resources over the last 20 years. Wetlands have been particularly vulnerable to conversion to hotel and marina sites, with consequent loss of fish habitat and sedimentation protection for offshore reefs. There have also been concerns about the effects of increased pollution from hotels and the growing concentration of yachts using the expanded facilities now available in Antigua. The number of tour and dive operators has also expanded, putting increased pressure on coral reefs from damage by anchors and other physical damage as well as spear fishing and other demands on the fish population. In addition, demands for fish and lobster to supply the hotels and restaurants have probably contributed to the pressure on these fisheries resources. Several beaches are important turtle nesting sites and there is potential for development of turtle watching as an additional tourist activity, but it would need to be carefully controlled.

2.2.3. Improving Management of Coastal Areas

The management of coastal areas is made difficult by the large number of different stakeholders and institutions involved in the use of these resources. The Fisheries Division is well placed to provide the major technical and regulatory functions, provided that mechanisms for input by the various stakeholders are incorporated when developing management plans, regulations and programmes. The resources available to the Fisheries Division are minimal and need expansion if it is to be able to carry out its responsibilities effectively. Considering the importance of the coastal zone in the development of the tourism sector, adequate finances for proper management of its development and regulation should be a high priority.

Public awareness of the importance of coastal ecosystems and how they function is important in directing public attitudes and opinion regarding development options for tourism and tourist related infrastructure, as well as the other land based factors such as siltation and pollution that affect coastal zone health.

The recent frequency and severity of damaging tropical storms and hurricanes has made many more aware of the fragility and vulnerability of coastal systems and of the need to retain and provide as much protection as possible. However, the difficulty of costing the negative effects of development that is not sustainable in the long term, makes taking decisions favourable to long term benefits difficult in the face of short term financial gain.

2.2.3.1. *Carrying capacities*

Mention has already been made of the concerns regarding the gradual depletion of fish stocks through overfishing. The growing number of tourists using the resources of the coastal zone are also putting increasing pressure on these resources and care needs to be taken so that they are not degraded. Better management techniques and practices, use of mooring buoys instead of anchors by tour boats on the reefs, for example, can help to increase carrying capacity, but in some instances, consideration may be necessary of limiting usage. Declaration and management of marine reserves is one way of approaching this problem.

2.2.3.2. *Balancing competing uses*

This problem is really the other side of the problem discussed above and requires a good understanding of the demands made by competing uses on the same resource, as well as the benefits, both financial and social, relative to particular uses of a resource. Beaches are important for tourism, for local health and recreation and for coastal protection. How should the competing use for building sand be balanced off against these other functions?

2.2.3.3. *Monitoring and Regulation*

Monitoring and regulation of the use of these resources is obviously going to become more important as the demands on these coastal resources becomes greater. The Fisheries Division is well placed to provide these functions, but will need additional resources if it is to provide an adequate service.

2.2.3.4. *Revenue generation*

At the moment, coastal resources are considered a common property available to all, more or less without restriction. Given the discussion in the above sections, this position may need to change in the future and some restrictions on use may need to be introduced as in the case of the Marine Reserves. This opens up the possibility of use being on a controlled basis perhaps regulated by issuance of licences or payment of a user fee. As with land based facilities for tours and tourist groups, it may be feasible to charge tour operators for use of a reef to help provide for maintenance of the facilities, such as mooring buoys. Such measures may well be resisted at first, but if introduced carefully and with adequate public information and explanation could possibly be accepted.

3. Common Management Issues

3.1. *Land Use Planning and Development Control*

The Development Control Authority has authority to regulate built development through the Land Development and Control Act (#15 of 1977), which provides for the granting or refusing of permission to develop land. Further, there are a number of legal instruments used to manage the upper watershed, prime among them being the Forestry ordinance (Cap 99, 1941) which provides for the establishment of forest reserves, the granting of permits for harvesting forest produce, forest clearing etc. Apart from the prohibition of forest clearing on steep slopes, the regulations of the Forest Law are almost completely ignored and exploitation for fuel wood and charcoal on both government and private lands is virtually uncontrolled. The Forestry Division of the Ministry of Agriculture does not have the manpower to enforce these ordinances, even if there was a policy to do so.

There is no single authority which has watershed management as its mandate, and many institutions have some responsibilities for coastal zone management. State lands for agriculture are allocated by the Extension Division of the Ministry of Agriculture. Parcels of more than 2 hectares are handled by the Lands Division of the same Ministry. Record keeping is antiquated at best and frequent disputes arise as to who has been allocated, what land.

At present, Antigua and Barbuda has no physical development plan to guide land use decisions in the country. A draft plan is now under intense discussion. The development and adoption of such a plan would help determine the way in which competing uses for the same land could be resolved in a rational way.

3.2. *Pollution and Health Issues*

In the last ten years, considerable effort has been made to better manage and control the disposal of solid waste in Antigua. All solid waste is now disposed of at a single, managed, disposal site, at Cooks, and other dumps around the island have been closed. This does not mean that unofficial dumping has been eliminated, but a significant proportion of solid waste is being disposed of at a managed site where some aspects of sanitary landfill practices are employed. The rate of growth of the site and the proximity to a major wetland area at the mouth of the Creekside watershed are some cause for concern, however. Movement of leachates from the dump site could pose a potential problem for pollution of both the wetland and the coastal area adjacent and the situation needs to be carefully monitored. There are still no proper provisions for the handling of toxic chemicals or biologically hazardous materials.

Management of sewage and other liquid wastes is still a serious problem, especially in St. John's, where there is urgent need to provide a proper sewerage system to replace the present system of septic tanks. With the population density of St. John's growing daily, the soil is incapable of handling the volume of septic tank effluent produced and the presence of these effluents at the surface, is evident in many parts of the city. Much of it drains directly into the St. John's harbour, where the water is severely polluted. Recently, there has been greater recognition of the need for better management of these liquid wastes, but the financial resources needed for a sewerage system may take some effort and time to find.

There is considerable pressure on hotels in the post-Rio environment to display greater environmental awareness and to conform their practices with environmentally correct principles. Perhaps as a result of

this, most of the larger hotels have invested in their own sewage treatment plants, which reduce the health hazards of the resulting effluent. In addition, some of the larger developments have an integrated system, such as at Jolly Harbour, where treated sewage waters are used for irrigation of adjacent grounds and golf course. Open air ponds help improve the final quality of water for irrigation, provide habitat for fish and add to the aesthetic appeal of the development. It is important that these systems continue to operate to a high standard, or adverse effects may arise. The Central Board of Health provided training for the operators of these systems some time ago, but this needs to be repeated on a regular basis to keep up with new entrants to the system.

Currently the CBH has no regular programme of monitoring the operation of these systems, but it plans to introduce a system of monitoring and reporting for the operators of these systems. This will provide more time for CBH personnel to focus on the problem areas. CBH has recently created and filled a new position in the CBH to manage this programme.

Most domestic premises utilize septic tank systems to provide primary treatment of sewage. However, apart from the problems already cited for St. John's, there is little monitoring of building practices by the DCA, so it is probable that many tanks are not properly constructed and in certain areas, this could lead to contamination of streams or groundwater through overflow or runoff.

Another general problem concerning sewage treatment is the disposal of bio-solid waste from package plants and domestic septic tanks. At the moment this is disposed of in a special area of the Cooks Disposal site. This poses a potential hazard, whereas alternative handling could turn this waste into a useful bi-fertilizer or soil ameliorant. Research is needed at a regional level to develop practical ways of utilizing this organic resource.

Antigua and Barbuda is not a heavily industrialised country and manufacturing is confined to paint production, appliance assembly and light engineering activities. There is therefore relatively low potential for pollution from industrial materials. The major sources of pollution are associated with agriculture, food and beverage processing and disposal of wastes, both liquid and solid.

Agricultural chemicals such as pesticides, herbicides and fertilizers are widely used in agricultural production. In some areas, agricultural production is carried out adjacent to surface water storage facilities and given the shortness of even the main watersheds, distances between most agricultural activity and water storage facilities are quite small, giving rise to concerns about possible contamination of the water sources, through chemical wash or percolation. The possibility is increased during heavy runoff. There has been at least one incidence of a fish kill at Potworks Reservoir, the cause of which was not confirmed, but agro-chemical poisoning was strongly suspected. Domestic water supplies are routinely monitored for biological contamination before distribution, but no monitoring of chemical contamination is carried out and facilities for such analyses in the APUA or elsewhere are inadequate.

Responsibility for importation and conditions for use of agricultural and domestic pesticides rests with the Pesticides Control Board, which was set up under the Pesticides Control Act (1973). However, the provisions of the act are rather limited and have not been fully enforced. A new act has been drawn up with the assistance of the OECS NRMU and is currently awaiting approval of the Legal Affairs Department for consideration by Parliament. The new act encompasses control of both pesticides and other toxic substances and would give the Board powers and responsibilities to register companies dealing in toxic substances, approve pesticides for importation and monitor use of such substances.

The Ministry of Agriculture is aware of the dangers associated with agricultural pesticides and has devoted considerable resources to training farmers through the Plant Protection Unit and Extension Division to adopt integrated pest management practices which minimise pest use. It has also utilized

external funds to promote use of biopesticides such as neem, in an effort to reduce the risks associated with chemical use.

The Central Board of Health is responsible for public health issues and has collaborated with the Ministry of Agriculture in activities such as Pesticide Awareness Week, where the dangers of chemical pesticides are highlighted and training in proper safety precautions is provided to the public along with suggestions for safer alternatives.

However, there is still no proper storage facility for disposal of toxic substances, either chemical or biologically hazardous waste and this poses problems for disposal of out of date chemicals.

Disposal of solid waste is handled by the newly created National Solid Waste Management Authority at a central disposal site at Cooks. This does not operate fully as a sanitary landfill, although this is planned to come on stream in the near future. The site is very close to a major mangrove wetland area at the mouth of the Creekside watershed. There are concerns about possible leakage of toxic leachates from this site into the estuary, especially during periods of heavy rainfall. Recently, disposal of cruise ship wastes, under the MARPOL agreement, has become an added responsibility of the NSWMA. A new site, adjacent to the present one, is in the planning stages. This will incorporate a properly lined site with separate treatment for hazardous wastes such as toxic substances and bio-hazards such as hospital waste.

Testing of inshore coastal waters near some of the heavily used beaches has been carried out over several years by the CBH. Results have not been reported publicly, but some concerns were expressed regarding levels of fecal bacteria in waters off some beaches. However, recent testing has indicated that the waters are at acceptable international standards.

3.3. *National Parks and Protected Areas*

Antigua and Barbuda has one national park. The National Parks Act of 1984 established one park, the Nelsons Dockyard National Park. The NDNP occupies over 3,000 ha or 8 percent of Antigua's land mass and has both terrestrial and marine components. The major focus of the National Parks Authority, which was set up to manage the park, is to create a world class tourism destination based on the historical and natural resources in the Park area. Major activities so far have concentrated on the upgrading of basic infrastructure, building an interpretation centre, revamping the dockyard museum and some stabilization of the historical structures. There has been very little emphasis on management of the biological resources, either terrestrial or marine, though an early development plan called for a land use plan, natural resources inventory, and an archeological survey.

There are two marine parks, one in Antigua and the other in Barbuda. Diamond Reef Marine Park (also called Salt Fish Tail Marine Park) was established in 1973 under the provisions of the Marine Areas, Preservation and Enhancement Act (No 5 of 1972). The 2000 hectare park is located off the north-west coast of Antigua. Palaster Reef Marine Park was established at the same time as Diamond Reef and is located off the southern tip of Barbuda. It occupies 500 hectares. Neither park is presently administered or managed as a protected area, but arrangements are now being made to demarcate the two areas. Cades Bay Marine Reserve was established in March 1999 and includes the marine and wetlands areas associated with the Cades Reef system. The Act establishing the reserve gives the Fisheries Division

powers to demarcate certain areas where fishing or other activities would be restricted or prohibited altogether.

Two areas were proclaimed as Public Parks under the Public Parks Ordinance (No. 4 of 1965). One area in Falmouth/English Harbour is now part of the NDNP, although the National Parks Act makes no mention of its existence. The other is a 47 hectare area in the Long Bay/Indian Town Creek area. It receives no special management or protection, so exists as a park only in name.

There are also forest reserve areas, established under the Forest Ordinance (Cap. 99, 1941) and the Forestry Regulations (SRO No. 13, 1941 & SRO No. 42, 1952, consolidated). However, these regulations are not effective and therefore offer no protection. Under the proposed Forest and Wildlife Act, presently under discussion, more effective powers would be assigned to the Forestry Division to enable them to manage such reserves.

3.4. Institutional Framework

3.4.1. Legal Framework

There are some forty six pieces of legislation governing the management of water resources, watersheds and coastal zone management or other aspects of the environment (Lausche, 1986). Some of these have been referred to already. The listing of key pieces of legislation is provided in Table 3.1.

It is clear that most of the legislation is outdated and does not reflect more current standards for natural resources management. Particular deficiencies exist in relation to management responsibilities for watersheds, proper protection of biodiversity, clearly enforceable laws regarding the issuing of permits and supervision of mining of any sort, especially sand. In addition, the laws need to be assembled in some more coherent manner rather than being scattered throughout the law books. Environmental impact assessments for development projects involving dredging, shoreline or marine construction, removal of mangroves, and large scale land clearing of any sort should be made legal requirements.

3.4.2. Institutional Framework

A large number of institutions are involved in activities associated with watersheds, water harvesting and treatment and with the marine and coastal zone. These institutions include government ministries, statutory bodies, NGO's and community groups. Some of the more important are described below.

The Ministry of Agriculture, Lands and Fisheries. This ministry has the broadest and oldest involvement with land and marine based natural resources. It is staffed with well qualified professionals in many areas, but frequently lacks the basic equipment and supplies to do an effective job. Professional staff are often not adequately provided with support staff having adequate training. The technical activities of the Ministry come under the direction of the Director of Agriculture, who heads the Department of Agriculture.

The Fisheries Division has responsibility for development of the fisheries sub-sector, monitoring fish stocks and marine resources, as well as a regulatory role in policing fishing practices. The Division is given powers under the Marine Areas Act (1972), to restrict fishing in certain areas and to preserve habitats, flora and fauna, natural beauty or shipwrecks in marine areas. These powers however, have not been exercised to any large extent due to inadequate resources.

The Forestry Division has responsibility for managing the country's forest and woodland areas and theoretically for reforestation. However, the Division is seriously under staffed and under budgeted, which makes it impractical to attempt any significant forestry development activities. In recent years, the Forestry Division has taken on activities more related to biodiversity conservation and to eco-tourism development, reflecting a more environmentally conscious thrust from the newly trained staff. Forest officers now regularly lead groups of cruise ship passengers on forest hikes. The Division has also been restricted in its work by the lack of adequate legislation to support its activities.

Table 3.1 Key legislation with relevance to water resources and coastal zone management. (After Lausche, 1986)

Relevant Area	Law
Land Use	Town and Country Act (Cap 278, 1948)
	Town and Country Planning Regulations (SRO No. 24, 1953)
	Land Development and Control Act (No. 15 of 1977)
	Antigua Agricultural Development Corporation Act No. 11 of 1978
	Crown Lands (Regulation) Act (Cap 130, 1917)
	The Crown Lands (Land Settlement) Regulations (SRO No. 24, 1930)
Agriculture	The Pesticides Control Act (No 15 of 1973)
	The Plant Protection Act (Cap 102)
Forestry	Forestry Act (Cap 99, 1941)
	Forestry Regulations (SRO No. 13, 1941 and SRO No. 42, 1952)
	The Bush Fires Act (Cap 62, 1901)
	Bush Fires Act (Cap 303)
Water	The Public Utilities Act (No. 10 of 1973)
	Watercourses and Water Works Regulations (SRO 23, 1954 and SRO No. 24 of 1961)
Beaches	Beach Control Act (Cap. 297, 1959)
	Beach Protection (Cap. 298, 1957)
	Beach Protection (Ammendment) Act (No. 1, 1968)
Marine	The Fisheries Act (No. 14, 1983)
	Fisheries (Protection of Lobster) Regulations (SRO No. 3, 1978)
	Turtle Ordinance (Cap. 333, 1927)
	Maritime Areas Act (No. 23 of 1986) (formerly Territorial Waters Act)
	Fisheries Regulations (No. 10, 1990)
Wildlife	Wild Birds Protection Act (Cap 115, 1919)
	Protection of Animals Act (Cap 113)
Protected Areas	The National Parks Act (No. 11 of 1984)

	National Parks (Amendment) Act (No. 3 of 1986)
	The Marine Areas (Preservation and Enhancement) Act (No. 5 of 1972)
	The Marine Areas (Preservation and Enhancement) Regulations (SRO No. 25, 1973)
	The Marine (Restricted Areas) Order (SRO No. 47, 1973)
Waste	Dumping at Sea Act (No. 29 of 1975)
Management	Public Health Act (Cap No. 236, 1957) and various regulations
	The Litter Act (No. 7 of 1983)
	The Litter (Fixed Penalty Procedure) Regulations (SRO No. 41, 1984) (and Amendment Regulations of 1985)

The Soil and Water Conservation Unit has responsibility for the soil conservation programme activity within the Ministry. It also assists farmers with development of irrigation systems, primarily in the area of mini-dam cleaning, repair and construction and in improving drainage. The two, well qualified, professional staff have only a small budget and workforce, so soil conservation programmes are very limited.

The Plant Protection Unit has responsibility for plant protection recommendations and provides pest scouting in the field for crops such as cotton. The Plant Protection Unit also has responsibilities for Plant Quarantine functions at the Ports of Entry.

The Veterinary and Livestock Division is headed by the Chief Veterinary Officer whose staff are concerned with both animal health and animal production issues. Animal quarantine matters are also the responsibility of the Chief Veterinary Officer. Animal production concerns include assistance with pasture improvement activities.

The Pesticides Control Board has responsibility for approving the importation, use and disposal of all pesticides used in domestic, animal and plant protection. The Board is composed of professionals in the Ministries of Agriculture and Health, including the Director of Agriculture and the Chief Medical Officer and representatives of the agrochemicals importers. Despite its existence since 1978, the Board has not been very effective and farmers and others have until recently imported whatever chemicals they thought effective. Recently, there has been a renewed attempt to work with Customs officials to be more alert to the requirements of the Pesticides Control Act. In addition, a new Act is in the final stages of preparation, which would reconstitute the Board as a Pesticides and Toxic chemicals Board with wider responsibilities including non-agriculture related chemicals and powers to licence and regulate commercial activity in this area.

The Lands Division is responsible for the management and control of all Government lands, including land reclamation, land use and the sub-division of land. Since a little less than half of the land is government owned, this Division has a key role in determining the conversion of land to non-agricultural uses. The Division is responsible directly to the Permanent Secretary.

The Extension Division has the major responsibility for farmer training and assistance and is also involved with allocation of state lands to farmers for agricultural purposes. Plots of up to 2 hectares (5acres) can be leased out under the authority of the Chief Extension Officer. The Extension Division is also responsible for control of stray cattle and provides land tillage services.

The Development Control Authority has responsibility for regulating the use and development of land for urban, economic and infrastructural development. The DCA currently is administered out of the Prime Ministers office, where a junior minister has responsibility for the DCA, Urban Renewal and public information. The DCA is currently in the final stages of developing a physical development plan for the country, which, if adopted and followed, could have significant implications for the management of both watersheds and the coastal zone.

The DCA is in the process of developing a GIS database of maps for the country and has been collaborating with the Environment Division and other Ministries regarding inclusion of environmental information. Limited resources to input digitized information has restricted the use of this system.

The Ministry of Tourism and the Environment was reorganized after the elections of 1999 when the Environment Unit was upgraded to a full Division of the Ministry and the number of trained staff has been significantly increased. It is evident that under the new arrangements, the Environment Division is going to play a more significant role in dealing with matters affecting the environment. This is being assisted by the resources being made available through the several environment related international conventions, which are now actively preparing studies and action plans. (See this section). There is increasing recognition of the role that the environment can play in developing the tourism product and the need to consider the natural heritage as a tourism resource.

Ministry of Planning, Implementation and Public Service Affairs This Ministry was also largely reorganized after the 1999 election and its role is now evolving. It is expected that the Ministry will provide the lead in integration of planning activities and will hopefully provide one mechanism to deal with overlapping responsibilities of different ministries. The Ministry is currently conducting a sectoral planning exercise with the objective of developing a national sustainable development plan. The Ministry also houses the Statistics Division, which is responsible for gathering and developing national statistical information.

Ministry of Public Utilities: This Ministry has responsibility for the Antigua Public Utilities Authority, a statutory body consisting of Electricity, Water and Telephones Divisions, which was set up under the Public Utilities Act in 1973. The Water Division has legal control over all water resources in the country and is mandated to provide supplies of water to meet the municipal needs of the country. However, agricultural needs are not dealt with under the Act and are therefore not officially part of its remit. The Water Division has made some concessions to agricultural water needs but there has been no active development of water supplies specifically for agriculture by the Authority. At times of drought, wells and reservoirs have been utilized for municipal supplies to the detriment of agricultural needs.

As mentioned in Section 3.1.3., there has been considerable expansion of water production in recent years with the commissioning of the desalination plants at Crabbs, which has eased the critical state of water supply in times of drought. However, little or no development of freshwater storage has been undertaken since the opening of Potworks Reservoir in 1969. A number of new wells have been dug in various aquifers, usually as a response to a drought situation. There is a Planning and Development

section of the Division which is responsible for hydrological studies, planning and digging of wells and building of dams. A water development plan that encompasses both municipal and agricultural needs does not appear to exist. Furthermore, the Water Division has no mandate or resources to manage the watersheds which supply the water it depends on. APUA does not operate any meteorological or gauging stations to collect data on rainfall, evaporation or streamflow at times of flood.

The Water Division is responsible for water quality testing and routinely tests water for residual chlorine levels and sediment.

The APUA operates a GIS facility and has a detailed set of digitised maps of Antigua and Barbuda

Ministry of Public Works and Communications: Public Works is a Department of this Ministry and is responsible for roads and drainage structures throughout the country. As such, the Department can have considerable influence on sedimentation management as part of road construction and maintenance and the management of flood waters. The Director of Public Works is also responsible for the enforcement of the Beach Protection Act, which is supposed to prevent the unauthorized removal of material from beaches or foreshores and for granting permits where permission is approved.

Other Ministries A number of other ministries are also involved to some extent in development, training or regulation of environment related matters that affect watershed or coastal regions. In fact, in such small land masses, almost any land based activity has the potential to affect one facet or the other.

The Ministry of Health and Social Improvement The Central Board of Health (CBH) falls under the administration of this ministry and is responsible, among other things, for enforcement of the environmental sanitation regulations, preventing the spread of infectious diseases, operating a mosquito control programme and for the handling of liquid and solid waste. The practical aspects of solid waste management have recently been transferred to the National Solid Waste Management Authority (NSWMA). The NSWMA was set up as part of a sub-regional programme to improve management of solid waste in the OECS and to provide facilities for the disposal on-shore of the growing amount of cruise ship generated waste as required under the MARPOL agreement. Theoretically, this leaves the CBH free to provide the regulatory role more effectively.

The CBH has also undertaken a programme of monitoring water quality at several of the main beaches around the island. Details of analyses are not published but do provide the possibility to the authorities to detect problems of water pollution at an early stage.

The Ministry of Education, Culture and Technology has the primary responsibility for education and training of children and young persons in basic and technical courses. As such, it plays a major role in influencing the knowledge and attitudes of persons in their formative years. There has been considerable effort to strengthen the curriculum in its treatment of the environment as a result of the growing recognition of its importance to the sustainable development of the country. This has also been evident in the focus of science fairs, essay competitions and other school based activity. More recently, the need for more direct training of primary school teachers during their teacher training has been recognised. Many of these needs were recognised over ten years ago (Hill, 1988)

Environment Related International Conventions

Since the Rio Convention on the Environment in 1992, which resulted in the adoption of several International Conventions on aspects of the Environment, there has been a steady growth of planning and enabling activities required by these conventions, which have broadened and strengthened the discussion and thought on environmental matters. Most of the conventions have concerns and plans of action, which have significance for watershed and coastal zone management.

Convention on Biological Diversity (CBD)

The CBD enabling activities are managed out of the Prime Minister's office. The major initial activity has been the production of a draft Plan of Action. The plan has highlighted the biological diversity that is currently existing in the Country and has proposed a programme of action to study, protect and conserve this biodiversity, while at the same time identifying opportunities to exploit such diversity in a sustainable way. Antigua's forests, wetlands and reefs form a dynamic repository of this resource.

Framework Convention on Climate Change

The Convention on Climate Change seeks to inform and prepare signatory countries for the likely consequences of global warming and sea level rise, so that, as far as possible, countries can prepare for it and take it into account in their planning. The worst effects are expected in coastal areas, where both sea level rise and the damaging effects of more frequent and more intense storms will be experienced. Watersheds and water resources are likely also to be affected by the more intense rains and droughts, causing accelerated erosion, flooding and species loss due to the more severe droughts which are expected. Management systems will need to be improved in order to prepare better for these eventualities.

Convention to Combat Desertification and Land Degradation

This convention focuses on the reversal of processes which, in many parts of the world, are leading to the creation of desert where there was none before. While desertification is an extreme scenario for Caribbean countries, many have experienced extensive land degradation due to deforestation of mountain slopes, leading to accelerated erosion and severe topsoil loss. This convention is coordinated within the Ministry of Agriculture, where experience with soil conservation and land management resides.

It is important that the several action plans being made under these various conventions be properly coordinated, so that best use of limited resources can be effected.

Non Governmental and Community Based Organizations

Non-Governmental Organizations (NGOs) have played an important role in the last ten years or so in drawing public attention to a number of important environmental issues, such as sand mining, solid waste management and the destruction of wetlands. The Environmental Awareness Group (EAG) has consistently raised issues of sustainable natural resource management. Many civic and community groups have participated in tree planting and beach clean up activities.

More recently the EAG has become involved in efforts to improve community management of coastal natural resources, providing training to stakeholders in practices that conserve reefs, off-shore island ecosystems and mangrove wetlands.

NGOs have also been active in improving education of teachers and students with respect to environmental matters including coastal issues. In general, the management and protection of watersheds has not been much emphasised. The Gilbert Agricultural and Rural Development Centre (GARDC) has also conducted courses in agriculture and rural crafts that emphasize the need for sustainable practices and effects of polluting chemicals.

3.4.2.1. Inter-agency Collaboration

Given the large number of institutions involved in some way or another in watersheds and coastal zones, collaboration among these organizations and institutions is necessary and important, if conflict and competition is to be minimised. At the moment there are very few formal attempts to provide this collaboration, most of which takes place either informally at a personal level or ad hoc through special meetings or workshops dealing with specific problems. More recently, activities associated with the various environment related conventions, such as biodiversity and climate change have provided opportunities and resources for inter-ministerial and inter-agency discussions surrounding their proposed plans of action and the government has set up a coordinating committee of these conventions which meets every few months.

With respect to the management of watersheds, a properly constituted Water Resources Board could provide a considerable degree of coordination among agencies such as APUA, Forestry and Soil and Water Divisions, as well as other stakeholders. The Fisheries Advisory Committee, established under the Fisheries Act, was intended to provide coordination and a broader input into the programme of the Fisheries Division, but it is not presently functioning and Fisheries staff are equivocal about its ability to function effectively. They prefer to see these aspects of collaboration and coordination tackled on a issue or problem basis, as this seems to provide a better chance for effective discussion and decision making to take place. At the moment, both Forestry and Fisheries Divisions seem to have a relatively good record of working with other government agencies, NGOs and community groups.

Nevertheless, weaknesses are apparent with respect to inter-ministerial collaboration. The involvement of the DCA, Ministry of Public Works and Communications, Ministry of Public Utilities/APUA and Ministry of Planning in discussions about water and coastal zone resources management issues has, in general, not been very consistent or effective.

3.4.2.2. Stakeholder Participation, Training and Awareness

It is now recognised that the active participation of all stakeholders is needed in planning and decision making activities dealing with natural resources. This has been emphasised by the planning activities of the environment related conventions referred to above. Difficulties are encountered, however, in many areas of natural resources management due to the absence of strong or effective commodity or community organizations, who can represent the views and concerns of farmers, livestock owners, fisherfolk and other users of forest or marine resources.

This weakness is recognised by both the Fisheries Department and institutions such as the Extension Division of the Ministry of Agriculture. Resources are now being directed more actively towards

encouraging formation of cooperatives or even informal groupings of farmers and fisherfolk at the community level or around a particular commodity. Certain NGO's such as the Environmental Awareness Group have also been active in this regard.

Such associations are also helpful in managing training activities amongst farmers and fisherfolk. The Ministry of Agriculture has active training programmes for farmers through the Extension Division and this training has covered topics of importance to watershed management, such as pesticide use and handling as well as safer pest management methods based on integrated pest management principles. Training in soil and water conservation as well as in use of drip irrigation techniques which conserve water, has also been provided. The Fisheries Division is also involved in training fisherfolk about better and more effective fishing techniques, navigation and outboard engine maintenance.

Given the large number of individuals involved in farming and fishing, it is a difficult task to provide adequate training to all who need it. It is important therefore to make the best use of limited resources and to find ways and utilize modern technology to reach as many persons as possible with the limited resources available.

3.4.2.3. *Community Management of Natural Resources*

It is also becoming recognised that communities of farmers or fisherfolk have a key role to play in the management of the natural resources that they depend on for their livelihood. The role of government agencies then needs to be redefined more towards providing these communities with the resources and training in management skills as well as the monitoring role to make sure that the management is effective and abiding by the pertinent regulations and laws. This will not happen quickly, but the intention needs to be taken into account in setting up management structures.

3.5. *Climate Change and Natural Disasters*

While the debate still continues as to how much the global climate has actually changed already, the Caribbean has certainly seen many of the predictions about global warming taking place. In particular, the predictions relating to increased numbers and severity of tropical storms has been very vividly experienced over the last ten years with the passage of five hurricanes and several tropical storms.

While the majority of hurricanes, especially Hurricane Luis in 1995, which caused major damage to homes and the country's infrastructure, have emphasised the need for better designed and constructed buildings and other infrastructure, the damage to land and coastal ecosystems was more evident with the torrential rains and heavy swells associated with Hurricane Lenny, where coastal roads were breached, roads were blocked with landslides and ghauts became raging torrents of water and sediment sufficient to completely change the land form in some valleys.

Antigua experienced over 250 landslides during the passage of Hurricane Lenny, most of these started on the steepest slopes and carried soil, rocks and vegetation with them. They emphasised the importance of good vegetative cover in controlling land slippage, as in most cases slides occurred where vegetation was sparse or scrubby.

More intense rainfall will lead to soil loss in sheet and gully erosion especially on the upper watershed regions. This effect will be exacerbated by severe droughts, which lead to loss of vegetative cover prior

to intense rains. The resulting silt load will reduce reservoir capacity and when flood waters reach the coast, if the wetland systems are inadequate to cope with the load, the silt will be washed into the sea and cause damage to sea grass and coral formations. These coastal systems will already have been stressed by the violent seas associated with these storms. The damaging effects are thus compounded.

Hurricanes also cause extensive damage to the plant and animal life and respective ecosystems of watersheds and in the coastal zone. Aside from the direct damage caused by high winds and flooding, the storm surges associated with hurricanes cause extensive damage to fishing ports and facilities and to resort or other facilities situated near beaches. Excessive beach erosion caused by these storms would seriously affect all associated ecosystems. Drought also damages the mangroves and makes them less able to cope with these other stresses.

Development practices have also contributed to threats to life and property by ignoring the official setbacks for construction and building solid structures within the active beach zone, which accelerates coastal erosion and the damage to property in times of heavy seas. It has also led to the construction of protective structures, which often accelerate the erosive forces. The indiscriminate mining of beach sand for the construction industry has resulted in severe beach erosion and in loss of protective vegetation. Dredging in some areas to provide access to shore facilities has led to coastal erosion in nearby areas during tropical storms

Sea level rise, outside of surges associated with tropical storms, has not yet been a significant factor in the coastal zone. However, all the problems discussed above will be made worse by any increase in sea level. It will also threaten the extensive tourism, energy, transport and communication infrastructure and human settlements, which are concentrated in the coastal zone.

Water resources may also be affected if rising sea levels cause significant intrusion of sea water behind current shore lines as this is likely to increase salinity problems in the groundwater supplies close to the coast. These effects may be particularly severe in Barbuda, where the major fresh water resources are very low lying and close to the coast.

Antigua and Barbuda are also subject to regular drought years when the already deficient rainfall may be further reduced to as low as 60% of the annual average. Apart from some predictive capability now available due to a better understanding of the El Nino weather phenomenon with which our drought periods are associated, little can be done until the natural water resources are better developed and managed.

Oil spills and other forms of pollution are also a threat, primarily to the coastal zone. Apart from the regional response mechanism, there are no contingency plans or equipment available. A recent incident with a super tanker, which ran aground off Antigua's west coast, has also revealed the need for adequate legislation to cover such kinds of damage.

Because of the frequency of major tropical weather systems (hurricane and tropical storms) over the past ten years, of necessity, the National Office of Disaster Services has had to concentrate on post disaster response to hurricane victims, and reduction of the impact of these events on human settlement. Until recently it had not addressed prevention of the secondary impacts resulting from compromised natural resources, such as landslides, on human settlements. Consequently, it has not been charged with any role that relates to prediction and early warning systems as mitigation measures. Because of the close proximity of some urban developments to threatened coastal sites, disaster preparedness measures for these areas will become more important in the future.

3.6. Data, Information Support and Research

Many of the issues and problems raised in preceding sections have been described in generalities as there is a lack of accurate and detailed information about the status of many aspects of both watershed and coastal zones in Antigua and Barbuda.

For the watersheds, baseline data regarding vegetative cover and land use or extraction of forest products, behaviour of water on the major watersheds, streams flows during periods of precipitation, the exact location and extent of ground water resources and their quality, is minimal or non-existent. Official precipitation information is now collected only at the Meteorological Services station at the V.C. Bird Airport. APUA does not collect any information on rainfall at any of its installations. The Ministry of Agriculture collects data from one or two additional locations and there are one or two private weather stations that supply information. This is totally inadequate for gaining proper information about watershed behaviour or for predictive purposes.

Accurate information regarding pesticide levels present in vegetation and soils or groundwaters in the major watersheds is also unknown. If incidents occur where toxic substances are suspected to be responsible, no baseline data for water, vegetation or marine life is available to compare with any samples taken at the site of the incident. Domestic water is not regularly monitored for chemical toxins or contaminants.

A similar situation exists for management of coastal areas. Besides the monitoring of waters close to six of the main tourist beaches by the CBH, for fecal contamination, there is no routine testing of marine or wetlands waters for pollution monitoring. Neither is the output of hotel sewage systems routinely checked.

Within the Ministry of Agriculture there is limited computerised mapping capability. The Fisheries Division operates a GIS system and has GPS equipment for its own use, but Forestry and Soil and Water do not have working systems yet. The Lands and Extension Divisions are still completely manual. Elsewhere, both DCA and APUA have their own GIS capability, including soils and land use information, but resources for printing maps are restricted. An attempt by the Environment Division to provide computing hardware, software and training in database management so that environmental information could be mapped and archived resulted in the distribution of a number of computers, but the training and database aspects have not yet been provided. Apart from this attempt to make data more accessible between ministries, there has been very little attention to the need for exchange of even the limited existing information.

The environment conventions, particularly the biodiversity and climate change conventions have resulted in some useful data collection and collation of information from many disaggregated sources into single documents.

Research capability in the Ministry of Agriculture is limited more by lack of resources for equipment and supplies than by manpower. For the most part, well trained staff are available, although, often, their diverse responsibilities and frequent need to travel out of the country on official business, make supervision of some types of research project difficult. Generally there is access to reasonable library resources and access to the internet has improved considerably in the last couple of years. Many staff members have their own computers and personal internet access, which they use for work related information access.

4. Integrating Watershed and Coastal Zone Management

4.1. *Problem Description*

Integrating the management of watersheds and coastal areas is considered necessary in small island developing states such as those of the Eastern Caribbean, because the small geographical scale of the islands makes both areas very interdependent. In particular, activities carried out in the watersheds are likely to affect the wetlands and reef systems downstream, because of their close proximity to each other. If lands are allowed to degrade through fires or overgrazing, the resulting erosion of exposed soil will inevitably add to the silt load being carried out to sea at times of flood, reducing coral growth and reef health. Similarly, pesticides or toxic waste, used or dumped on the land, may be washed into the streams and carried to the sea, where marine organisms may be affected. Many other examples of this linkage could be cited.

Despite the critical importance of water and the coastal resources to the economy of the country, very little attention has been paid, or resources devoted to managing either of these resources. This situation probably results from a number of different factors, which are outlined below.

4.1.1. Lack of Awareness

Most people do not have much understanding about watersheds and how they function. The effects of deforestation or burning of vegetation on water supply are not immediate and obvious for everyone to see. When floods occur, it is not possible for most people to connect this event with land clearing that is separated both in time and distance from the result. The difference in behaviour of a forest covered hillside and one covered only in scrub or grass may be noticeable if the clearing takes place over a short period of time and is promptly followed by heavy rain, however, if, as is more often the case, the degradation is gradual, the connection between cause and effect is obscured.

Similarly, the connection between a forest covered hillside and the recharge of groundwater supplies is very difficult to make, especially when adequate data to measure rainfall and groundwater resources is not available.

Effects on the marine environment are often more difficult to observe. Unless a person is a diver, who visits a particular reef regularly over a period of time, gradual changes are difficult to detect. Even then, the connection with events occurring in the hillsides, several kilometres away will not be obvious. Sudden changes, such as damage following tropical storms are more dramatic and immediate, so the connection is easy to make.

While these observations may apply to the general public and even to many stakeholders, they may well be true for some non-technical decision makers in ministries and government agencies, who often are not familiar with either forest areas or the marine environment. Low levels of awareness will result in low priority being attached to such matters, even where the end result, such as water shortages and declining fisheries resources are quite important to the economy of the country.

4.1.2. Weak Policy Framework

Discussion in previous sections has alluded to the absence or weakness of policies to guide development and management of water resources, watersheds and the coastal zone. It is difficult to manage a resource effectively in the absence of a clearly defined policy, especially where the resource is used by a large number of different stakeholders, whose needs must all be taken into account. A long term approach is also necessary in managing natural resources, as biological processes take some time to take effect. A reforestation programme, for instance, will take almost a decade before its effects will begin to be significant.

Weaknesses in this area are not confined to natural resources management and are to be found in other sectors of the economy. They have more to do with the general approach to management and style of government. However, in the case of natural resources, lack of action usually results in changes that can not be reversed, or only at great expense.

4.1.3. Division of Responsibilities

The management of Antigua's coastal areas involves a large number of government departments and agencies as well as different groups of stakeholders. When watersheds are included, the list is even larger. Figure 4.1 attempts to identify the interrelationships of the stakeholders and institutions that need to cooperate to varying degrees in the management of watersheds and coastal areas. It is evident that a great deal of inter-ministerial and inter-agency cooperation is needed. At present, this is mostly informal and takes place on a personal basis rather than through committees or inter-agency institutions. This can lead to difficulties when there are personnel changes, but the lack of adequate resources frequently necessitates collaboration, as between the Fisheries Division and the Coast Guard, which facilitates their sea transport. Given the relatively small number of persons in each institution, such informal collaboration may well be more efficient than forming committees, provided the necessary legal authority is present for the responsible agency to act.

4.1.4. Fragmented Legal Support

There is legislation pending in a number of areas, which need urgently to be finalized and enacted. The Forestry and Wildlife Act has been in preparation for nearly ten years and is probably already outdated. It would however provide the Forestry Division considerably greater powers to declare and manage forest reserves. The Pesticides and Toxic Substances Act has also been sometime in the preparation stages. This Act would strengthen the powers of the Pesticides Control Board to limit importation, require training of pesticide operators, and generally regulate the way pesticides and toxic substances are traded and used.

As described in Section 3.4.2., the legislation governing use and management of coastal resources has developed piecemeal and is scattered through at least eleven separate pieces of legislation. Even if the laws were consolidated, a considerable degree of amendment would be needed to make the legislation comprehensive. There have, however, been several improvements to the legislation in recent years, but there are still weaknesses in several areas. The scattered nature of the legislation makes it more difficult to work with.

Figure 4.1 Interrelationships among stakeholders and management agencies dealing with watersheds and coastal areas.

See file: (figure4_1.pdf)

The situation with the legal framework covering watersheds is even more sketchy. There is no legislation dealing specifically with watersheds. The new legislation under consideration for Forestry and Wildlife management does refer to the declaration of forest reserves for conservation of soil and water and would give the Forestry Division better authority to manage government lands that serve as watersheds. However, this legislation has been under review for ten years and is yet to be adopted.

4.1.5. Weak Financial Support

By and large, national budgetary support for natural resources activities within the country is minimal and until recently, when environmental matters have been receiving the attention of developed countries following the Earth Summit in 1992, were also not high priorities of the international donor agencies. The Forestry Division, for instance, has remained very under staffed and poorly equipped and has been unable to carry out any meaningful reforestation programme.

This situation may stem from the lack of awareness and interest alluded to above, but may also be contributed to by the difficulty of quantifying the benefits of natural resource activity. The contribution of forests or coral reefs is much less clear than a new school or hospital because of conventional accounting systems. The reverse side is also true, that is, that the cost of damage to natural resources is also difficult to quantify. Who pays, for instance, for the damage done to roads or property when beaches, denuded of sand through sand mining, are unable to protect the shore line in times of storm.

The resources now being provided through the programmes of the various environment conventions must somehow be made to improve the willingness of decision makers to invest in natural resources. One avenue towards this objective may be to develop the linkage between tourism and the natural resources sector as much as possible, since the value of providing an attractive tourism product is readily understood and accepted.

4.2. Goals of Integrated Management

The above discussion has attempted to describe the major problems that prevent better and more integrated management practices being adopted for the management of watersheds and coastal areas. The goal of revising and integrating the management structures is to enable the land and marine areas to provide the optimum level of resources on a sustainable basis. Without a high level of management, the water, forest and marine resources of the country will not reach their optimum potential.

4.3. Key Issues in Developing an Integrated Plan

4.3.1. Land Use Policy

A key element in the integrated management of watersheds and coastal zones is the need for a clear policy and plan for the development of the land resources of Antigua and Barbuda. At present, there is no clear policy for the development of the country's land resources and decisions about siting and

approval of development proposals are made on an *ad hoc* basis. This has far reaching implications for recognition and management of watersheds, designation of forest and marine reserves as well as the conservation of wetlands and management of coastal development. All of these issues can have knock on effects on the health and management of the marine resources as well as disaster management strategies. However, this situation may improve if the draft land use plan for Antigua and Barbuda currently under discussion, is adopted.

The National Physical Development Plan now under discussion lays out a fairly clear policy for the development of the land resources of the country. Adoption of this plan by the government after the necessary public discussion and amendment will assist considerably in the development of an integrated approach to land use.

The plan proposes to place much of the upper watersheds in conservation areas, which should assist in retaining these areas as forest and would facilitate the Forestry Division in its ability to create new watershed reserves. The plan also recognises the importance of the remaining wetlands and proposes to conserve these as much as possible. Soils rated as class 2 or 3 (there are no class 1 soils) will be retained, in general, for agricultural use. The plan does not appear to provide any reservations of land for increased water storage, so this may need to be addressed.

In order for the plan to function, there will have to be general recognition of the need for such an approach to the country's development and the function of the Development Control Authority will need to be strengthened to make sure the plan is adhered to. The relationship of the DCA with the Ministry of Planning may also need to be reviewed with a view to improving the liaison between these two agencies integrally involved in national planning. Other agencies involved in land use such as the Central Housing and Planning Authority, Public Works Department, Ministry of Agriculture (Lands Division, Extension Division etc.) will need to be thoroughly appraised of the plan and brought on board, if the plan is to be implemented without major difficulties.

Public awareness of the plan and discussion about its provisions will be important in obtaining general acceptance of its provisions.

As part of the land use plan, policies on adequate setbacks for beach front development need to be adopted and decisions regarding measures to mitigate further damage where existing buildings are causing problems will also need to be taken.

4.3.2. Watershed Development

It is likely that the Forestry Division will continue to be the major organization responsible for watershed management. It is therefore important that the Forestry and Wildlife Act, which has been under discussion for several years is finalized and adopted without delay. This will give the Forestry Division some of the authority it needs to carry out programmes, which can improve the functioning of the major watersheds. There is little public appreciation of watersheds and how they affect both water resources and flooding as well as the linkage between degraded watersheds and damage to reefs and fisheries. There is a need therefore for increased public awareness about the effects of burning, overgrazing and forest destruction on water supply for the nation as well as on the health of our beaches, coral reefs and the livelihoods of our fisherfolk.

The draft Pesticides and Toxic Chemicals Act should also be finalized and adopted into law. This will provide additional support for the Pesticides Board and the Ministry of Agriculture to improve

regulation of the use of these substances and to monitor their use and possibly assist in setting up periodic monitoring of such chemicals in the environment. This could have important implications for both watershed and coastal zone management.

4.3.3. Water Resources

The difficult question of water resources management needs to be resolved without further delay, since some options for development of these resources may not remain open much longer. The need for a Water Resources Board has been discussed already (Section 2.1.6.3). It will probably be a matter that the Ministry of Agriculture will have to raise for discussion at Cabinet level, since agreement with other Ministries, in particular the Ministry of Public Utilities, will be needed and new legislation will be required.

A Water Resources Board composed of representatives of the various stakeholders, as well as the Public Utilities Authority, should be able to bring a much broader perspective to the development and conservation of water resources. Currently, the Water Division's responsibility is defined by the Public Utilities Act, as to provide water for the domestic needs of the nation. The Division's main interest is the sale of water to consumers. It therefore has a restricted focus and its concern with issues such as development and conservation of water resources is not likely to receive a high priority. In the absence of a more sustainable government policy regarding water resources, this situation is likely to lead to further reliance on desalinated water, at high cost to government or the consumer and under-development of water resources for agriculture.

4.3.4. Coastal Areas

Weaknesses in the existing legislation with respect to liabilities for damage to coral reefs by non-tourist activities, were discovered recently when a super tanker ran aground and did extensive damage to an off-shore reef. The fisheries legislation needs to be up dated to accommodate this type of threat and provide suitable penalties for such damage.

An additional marine reserve is planned for the north east coast and off shore islands. This needs to be declared as soon as possible as the area is under considerable tourist pressure.

Workable policies regarding provision of sand for the construction industry need to be developed. Until this is done, no matter what legislation is adopted, it will likely remain unenforced because the underlying need has not been met. Consideration of the feasibility of the importation of sand from sources such as Guyana should be made and if necessary, a proper study of the risks and feasibility of mining sand from deposits far off shore. The laws regarding permission for beach mining should be reviewed and adequate provisions for consultation before granting the licence and regulating the conduct of the extraction should be made.

The DCA should be required to consult with the Fisheries and Environment Divisions when considering proposals for development of shore line properties, to make sure that protection of the marine environment is given sufficient consideration. The DCA should require independent environmental impact assessment studies for any development proposal that involves extensive land clearing or movement especially in areas close to the coast or to inland water resources and likewise for any

development that involves use of any toxic substances. Similar requirements should be considered for activities of the Public Works Department.

4.3.5. Public Awareness

As has been alluded to previously, there is need to raise public awareness regarding the importance of watersheds and the role they play in providing water resources. The relationship between degraded watersheds and damage to coral reefs and beaches also needs to be stressed. There has been a good deal of public education about mangrove wetlands, but the role of watersheds has not received the attention it deserves in a country critically short of water resources. Land degradation and forest resources are of basic importance to concerns about biodiversity, climate change mitigation, and desertification and should also be linked to potential for eco-tourism development.

An awareness programme needs to be targeted to several different groups and should include the general public, schools and other educational institutions, specific stakeholders, especially watershed users, decision makers and possibly the media itself, so that they themselves have a better understanding of the issues and relationships.

4.3.6. Inter-Institutional Cooperation and Liaison

The need for increasing inter-institutional cooperation and liaison among agencies with management responsibilities has been raised in several sections of this report. Discussions with key persons involved with management of watersheds and coastal areas have made differing responses to this issue. While all acknowledge the need for high levels of collaboration, there is no agreed approach on the best way to achieve this. Some have favoured the establishment of "super committees" being set up to coordinate management, while others have questioned the effectiveness of this approach, suggesting that these types of committee, with a very broad focus frequently become little more than talk shops and actually accomplish little. It has been suggested that the Fisheries Advisory Committee is an example of this and its non-functioning in the recent past is attributed to its poor record of achievement.

The alternative suggestion has been to retain the present system of informal linkages, especially where these are working reasonably well, but to support them with activities, such as workshops and seminars, which focus on the solution of specific problems. It is felt that these activities are more likely to achieve more practical cooperation.

However, there are situations, particularly where demarcation of legal responsibility or conflicting approaches by separate institutions are concerned, where there is need for an "official" body to broker agreements and adjudicate disputes. A particular case which might fall under this description is the issue of water resources management, where the establishment of a Water Resources Board would seem to be the best way to enable all sides to develop agreement on an equal footing.

The main agencies responsible for management of watersheds and coastal resources are the Forestry and Fisheries Divisions and Soil and Water Conservation Division in the Ministry of Agriculture, Lands and Fisheries. There has been a suggestion that it could assist the management of watershed and coastal resources if these three agencies were more closely tied together organizationally in a Natural Resources Division or even as a separate ministry. The implications of this are not clear, but since one positive

result could be a better base for attracting funds from natural resource orientated funding organizations, the suggestion merits further discussion.

In summary, it is suggested that the approach to this issue should be taken on a case by case basis, taking into account all the factors involved, rather than to make a general prescription.

4.3.7. Stakeholder Involvement and Community Management

The complexities of stakeholder involvement are clear from the relationships shown in Figure 4.1. Nevertheless, it is important that management decision making systems promote the development of stakeholder involvement and recognise the expansion of stakeholder ability to manage natural resources as an ultimate goal, since it is clear that the State does not have the resources, either financial or human, to do all that needs to be done. Stakeholder consultation and involvement is being promoted by several factors. At a government level, there is increasing recognition that stakeholder involvement is a positive part of development planning. Some recent examples of this recognition are the development of the National Physical Development Plan by the DCA and the efforts of the Ministry of Planning to prepare a national strategic development plan. In both cases, besides extensive consultation among other government ministries, there were public seminars and the plans were taken to the communities for discussion and input at the community level. The NPDP was also made available on a web site.

There has been renewed interest and a more positive attitude towards promoting producer, commodity and community groups in the last few years. Perhaps this is more evident among farmers than among fisherfolk, but there is a new spirit to try again to persuade producers that the practice of relying on government to supply all their needs and make all their decisions is no longer tenable, even if it once was. Producer cooperatives have not had a very successful history in Antigua, but the new approach is somewhat more flexible and is more willing to let the form of organization develop with the group. Further, it is recognised that extensive training and guidance is required to help the proto-organizations develop a supportive foundation. The emphasis has shifted to the practicalities of cooperative action rather than focussing on setting up formal structures where position and authority can become dominant objectives at the expense of group improvement.

International donor agencies have contributed to this movement by providing resources to help such groups to develop, making opportunities for them to contribute to discussions and decision making in natural resources management and environment related projects which they fund. Conventional management agencies in government have not always welcomed this development, seeing such groups as a challenge to their agency's authority. However, there have also been some successes where producer groups, NGOs and community groups have developed good working relationships with government agencies and have made significant contributions to the management of natural resources. This process needs to be supported as much as possible, for the long term good of both the producers and the natural resource.

Attention to gender issues within the area of natural resources management has largely centered on providing training to women in rural enterprise development. This has included courses in agricultural business development and various craft enterprises using local natural products. These courses have been provided by the Gilbert Centre for Agricultural and Rural Development. The Ministry of

Agriculture, Extension Division has also supported the Women's Farmer group, which functions as a loose cooperative of women farmers. While this does not necessarily guarantee that women's concerns are adequately addressed, it is a fact that many technical staff including heads of divisions in the Ministry of Agriculture, Lands and Fisheries, and the Environment Division, are women.

4.3.8. Capacity Building

Many references have been made to the lack of physical and material resources in the various government agencies responsible for watershed and coastal area management. In general, it would seem that these are more lacking than human resources, where on the whole there is a reasonable pool of quite well trained professional staff. The productivity and effectiveness of these staff is frequently limited by either the lack of facilities, or in some cases, well trained support staff or labour; and not infrequently by organizational structures within the Ministries which restrict their ability to function.

Ministry of Finance officials have taken the view that the programmes of the various ministries need to be projectized and that much of the resources for equipment and supplies should be sought from externally funded projects, because the government simply does not have the resources to provide all that is needed. While there may have been some reluctance to accept this policy among some professional staff, a major problem has been the lack of skills and experience with project development. The Ministry of Agriculture, for example, does not have a planning unit or even an individual with the sole responsibility of assisting staff with the development of projects. Project financing requires considerable knowledge about funding sources and skills in budgeting and project writing, given the often complex procedures of many donor agencies. The Global Environment Facility has been unusual in providing considerable resources to assist in the development of projects for funding in its programmes. The Natural Resources Unit of the OECS has made considerable efforts to improve planning capabilities with respect to natural resource management, but more needs to be done.

Further attention should be given to improving the planning capabilities in those Ministries involved with watersheds and coastal areas, especially in the areas of project preparation and management.

There would appear to be weaknesses in the technical skills and environmental training of professional staff in agencies such as the Development Control Authority as well as the Public Works Department and this is an area in which the Environmental Division could perhaps become involved. Their work with the legal and protective services has been mentioned already. Architects and developers also are not very technically aware of the possibilities for waste water treatment and utilization.

4.3.9. Research, Data management and Decision Support Systems

Information is a basic weakness in the whole management system. Many management decisions are made on the basis of casual observations, extrapolation and educated guesswork. Hard information to support technical advice to government decision makers is frequently not available.

This is a result of inadequate research and data collection and sometimes the fact that the limited amount of information gathered is not processed or made easily available or accessible, even within the same Department or Ministry, much less among different ministries. Computers are now much more common than even two or three years ago, but data handling and processing procedures have not changed sufficiently so as to make full use of the data handling and storage capacity of the computers

available. The Ministry of Agriculture is currently considering the establishment of an information unit, which, if implemented, should improve information resources and use.

Much of the data relating to natural resource management has a strong spatial component and GIS capabilities are important in managing and utilizing this information. As discussed in Section 3.4.4., some advances have been made in the acquisition of GIS capability but the information now available in these GIS systems is not as easily available to those who need to use it, as is required for efficient management. Training in GIS is also needed to enable more staff to access and use this kind of data. In addition, more persons need training in operating and managing geographical information database systems.

The need for much more comprehensive baseline data on levels of toxic chemicals in all parts of the environment has been stressed already (Section 3.2.2.). Sound management of watersheds and coastal areas can not continue to rely on assumptions about presence or absence of pesticides close to or in ground water or in surface water catchments. Similarly, movement of toxic substances, if they are present, along watercourses and to the coastal environment needs to be measured and understood. Baseline levels of pesticides or heavy metals in fish or other aquatic organisms need to be established so that any increase will indicate a new source of pollution. This kind of data is needed urgently and may well be required by the new pesticides and toxic chemical legislation, when it is adopted. While the Government Chemist's laboratory has equipment needed for some analyses, several key gaps in the equipment or supplies remain. Facilities for preparing large numbers of routine samples for a baseline monitoring programme are not available. Consequently, this would appear to be a good candidate for a regional project in which, local laboratories are upgraded in equipment and training to pre-process samples for safe shipment to a central laboratory, such as at CEHI, for the analyses requiring specialist equipment or operating skills.

4.4. Financial Resources

4.4.1. Internal

At present, local financial support for natural resources programmes is very limited. Government revenues derived from traditional sources such as import duties are likely to diminish substantially as the requirements of membership in the WTO are implemented. Real revenues from tourism have suffered from the move by several of the largest hotels to the "all inclusive" mode. Cruise ship tourism brings large numbers of visitors but these only stay for a few hours before returning to their own "all inclusive" ship. There is therefore little prospect in the short term for government revenues available for natural resources management to increase significantly in the near future.

It would appear necessary to entice as many passengers as possible to leave their vessels, by offering a wide range of different experiences, for which they are willing to pay. This suggests that, among other things, many different forms of eco-tourism need to be experimented with and developed in a sustainable way so that revenue generated by this means can be turned back into providing resources to assist in the management of forest and watershed reserves and coastal zones. This could help supplement the meagre resources that can be extracted from local use of these same resources through user fees, licences and permits. If ten percent of the approximately 250,000 cruise ship passengers that visit Antigua and Barbuda annually, contributed EC\$ 10 by visiting a recreation site, that could provide

EC\$ 250,000 towards natural resource management and development. This could be done at very little development cost and could put a much larger sum into the local economy.

4.4.2. Regional and International Assistance

Donor funded projects offer sometimes the only avenue for projects which require a significant expenditure on technical assistance or capital development. There is probably considerable potential for funding of natural resources activities if the action programmes that are being proposed under the various environment conventions, such as climate change, biodiversity and land degradation, can be properly coordinated and designed. As these programmes are developed, the National Coordinating Committee will have to play a major role in helping to see that this coordination takes place. Considerable effort will be needed to reduce regional bottlenecks and delays in approval of proposals and work plans.

5. National Action Programme to improve integrated management of Watersheds and Coastal Areas

5.1. Policy and Legislation

5.1.1. Action 1: Enact all pending legislation relating to watersheds and coastal zones

The responsible ministries should make every effort to finalise versions of draft legislation now under discussion or amendment and bring them to Legal Affairs for ratification and submission to Parliament.

The Ministries may need assistance from a qualified legal draughtsman, experienced in environmental laws to assist in making the necessary amendments and preparing, in consultation with the relevant staff, a brief for Cabinet concerning the need for, and benefits accruing from, the particular legislation.

Laws under consideration include:

Draft Law	Ministry/Agency Responsible	Comment
National Physical Development Plan	Development Control Authority	Final draft stage
Forestry and Wildlife Act	Forestry Division/MAL&F	Final draft stage
Fisheries Act	Fisheries Division	Under Discussion
Environmental Health Act	Central Board of Health	Final Draft stage
Solid Waste Management Act	Central Board of Health	Being reviewed

It is recognised that enactment of legislation is only part of the process. Compliance/ enforcement issues are also critical for the legislation to make any difference to public behaviour. In this regard, it is very important that the introduction of the legislation is accompanied by an education programme, which focuses not only on the actual provisions of the new laws, but on the reasons for them. It is anticipated that this should be tackled in two stages. The first stage would provide general information about watershed and coastal area issues. This should be an important output of the Demonstration Watershed Project articulated in Section 5.2.1. Information relating to the specific legislation should be prepared at the time of enactment and could be provided as part of the services of the legal drafting/promoting team proposed above. It will also be important for the responsible agencies to address any changes to their human resource needs required by the enforcement aspects of the legislation.

Another important factor impinging on the enforcement/compliance of environmental laws relates to stakeholder participation in management of the resource. Where this participation is well informed and adequately involved, the chances for community support of enforcement and a degree of self

policing are much improved. This has been demonstrated in several community based management projects in the region.

Another aspect of enforcement relates to the specific role of the enforcement agencies and their own level of understanding of the need for enforcement. This is often lacking and infringements are often considered trivial in nature. To this end, education of the police and legal profession regarding environmental issues is needed. The Environment Division has already held meetings with these bodies to begin the process, but the process will need to be continued.

Harmonization of the many pieces of legislation dealing with watershed and coastal area management is urgently needed. However, given the past history of environmental legislation in Antigua and Barbuda and the slow pace with which it has been adopted, it is felt that the better strategy is to secure the benefits of the legislation currently ready for adoption, rather than waiting for the development and agreement on more comprehensive environmental laws.

5.1.2. Action 2: Policy Adoption - Water Resources Board

A proposal has been made in this report and in the draft Agriculture Sector Plan, for the establishment of a Water Resources Board, which would assume some responsibility for functions now vested in the Antigua Public Utilities Authority.

It is recommended that this proposed policy change be formally discussed and a recommendation be put to Cabinet on the matter.

5.2. Public Awareness, Data Gathering, Training and Demonstration

5.2.1. Action 3: Demonstration Watershed

5.2.1.1. Goal

The overall purpose of this action is to develop a model that can be used to optimise the management of watersheds and associated coastal areas.

5.2.1.2. Objectives

The specific objectives are listed below:

- 1) To develop a small, well demarcated watershed according to best practices available
- 2) To gather baseline data and monitor the changes taking place as a result of the development of the improved management of the watershed.
- 3) To also gather base line data in the associated coastal zone and monitor changes with time
- 4) To use the model watershed as a demonstration to increase public awareness and understanding of the consequences of land degradation and forest removal on water resources, biodiversity and possibly on reef quality
- 5) To work with local stakeholders and user communities (farmers and livestock owners, charcoal burners and other forest produce users) to develop management systems which can meet the needs

of all users as far as practicable and can arrive at an equitable allocation of forest/watershed resources.

- 6) To work with the Public Utilities Authority (or Water Resources Board) to gather data (stream flow, percolation, groundwater recharge, siltation etc.) on the effects of the improved watershed management on water resources in the model watershed.
- 7) To involve all relevant institutions and agencies, including NGOs/CBOs, and to develop appropriate mechanisms of cooperation and collaboration.

5.2.1.3. *Justification*

The analysis of issues confronting the integration and optimization of management of watersheds and coastal zones has highlighted many separate weaknesses, which are in many respects interrelated. They start with poor public awareness and understanding, which leads to low priority and inadequate funding. The resulting lack of resources make impossible any meaningful impact on the whole problem of watershed management.

This project, however, proposes to focus on a small, well chosen watershed, preferably with its own exit to the sea, or water storage facility, which can be managed with the resources provided by the project, and which is chosen to respond quickly and significantly to the improved management practices.

The application of a set of "best practices" to this model watershed would provide the opportunity to do research, gather data, develop data bases, work out management systems, educate and involve stakeholders and at the end have a living demonstration of the positive effects of such "best management practices". The impact of a well forested watershed, better stream flow and increased water resources which is expected to result, could be worth a great deal more in persuasion and encouragement than many reports or statistics.

The model will serve as a testing and learning tool for the development of a programme to tackle the bigger job of managing the main watersheds. The model watershed, if suitably chosen, can also be used for teaching and as a tourist attraction.

5.2.1.4. *Outputs*

The model will provide a visual demonstration of what a well managed watershed is and the tangible benefits that it can bring to an area.

The model will also provide some much needed data for improving the management of watersheds and understanding the behavior of the watershed with respect to erosion control, water run-off and infiltration for recharge of groundwater supplies.

The process will result in the reforestation of a small, but significant area of the main watersheds. In addition, improvements in biodiversity, tourist amenity, and increased supply of forest produce from the managed areas can also be anticipated.

The process of setting up the model will allow development of management strategies which take into account the needs of all stakeholders, as well as strategies for dealing with the serious problems of uncontrolled grazing and burning of watershed lands.

5.2.1.5. Time Frame

The project will require a long term investment of financial and human resources, but providing the area is kept small, while encompassing the necessary features which will provide a suitable testing ground and demonstration area, the cost need not be unmanageable. At least five years will be required to establish new vegetation to the point where less intensive management is required. Full benefits will probably not be observed in less than ten years. Careful consideration will have to be given to use of quick growing species in the reforestation activities or to slower growing hardwood species more typical of mature forest systems.

5.2.1.6. Funding

Details of the inputs required for the project will need to be worked out, but it is hoped that a significant proportion of the resources needed can be provide by donor organizations. It is quite possible that the model watershed concept could fit into the work of other funded programmes such as the UN Convention to Combat Desertification, which has important concerns about land degradation. The Convention on Biological Diversity may also see opportunities to improve *in situ* conservation of certain native species. The model watershed concept could provide a useful focus for coordinating the activities of the various environment related programmes.

5.2.1.7. Project Management

It would probably make best sense if the Forestry Division in the Ministry of Agriculture, Lands and Fisheries were to provide the lead role. The Soil and Water Division, APUA and Fisheries would also need to be involved. The Chemistry and Food Technology Division and Central Board of Health, might also be required to assist in pesticide monitoring activities.

5.2.2. Action 4: Natural Resources Database

Frequent mention has been made of the poor quality of the data resources available to those making resource management decisions. Either data is not available, or it is not in a form which allows it to be readily available. Sometimes personnel have insufficient training to access or utilize it.

This element of the action plan would build on the start made earlier by the Environment Division to provide computer capability, software and some training to start building a network of linked databases. This would make accessible much of the information on land, soils, biodiversity, pollution, water resources, and other environment related information, which is presently held in several different ministries and is otherwise not easily accessed.

Establishment of such a database would encourage users to add additional information as it is produced, so that with time a comprehensive collection of information would be available to all potential users.

The original project did not accomplish its intentions because insufficient resources were devoted to training staff in its use, sorting out the problems of linking together the separate databases each in housed in individual computers and management of the data.

This can be seen as an institutional strengthening action as well as a program to improve the data available for decision making through exchange and networking.

6. Recommended Inputs to Regional Action Programme

6.1. Regional toxic substances monitoring programme

6.1.1. Goal

The goal of this programme is to obtain a thorough understanding of the levels and sources of pollution by toxic chemicals such as pesticides and other persistent organic pollutants as well as inorganic toxins such as heavy metals in watersheds, water resources and the coastal environment of the region or specifically the OECS countries.

6.1.2. Objectives

The project would have several objectives, which are listed below:

- 1) To undertake a review of all studies monitoring levels of toxic substances in the environment, including water resources, watersheds, and coastal marine areas, in order to assess the current state of knowledge with respect to the fate of pesticides and other persistent pollutants.
- 2) To undertake a survey of current levels of pesticides and other toxic substances in the environment. This should include studies of the soil, plants, water (both fresh and marine), fish and other marine organisms as well as food, found in target areas of the participating countries. The information would be used to form a set of base line data for soils, waters and organisms in the region. The information would also provide a guide to the key pollutants which are likely to cause, or are already causing, pollution problems in the region.
- 3) To develop a system of laboratories and protocols for handling a continuing programme of routine monitoring of pollution levels in key environments throughout the region, as well as a system to respond to specific incidents such as fish kills, where toxic substances are suspected. It is expected that at least one laboratory in each country would be trained and equipped to handle a core of basic tests and preparation of samples for further analysis requiring highly specialised equipment which it would not be reasonable to have available in all countries. These specialised laboratories would be equipped to carry out a full range of tests against a comprehensive range of pollutants.
- 4) To maintain common standards among laboratories in the region by providing a facility for exchange of samples and subsequent analyses as a cross check on accuracy and proper functioning of equipment.

6.1.3. Justification

Improved facilities are needed for regular monitoring and rapid analysis of both fresh and coastal waters for chemical pollutants, which at the moment are not adequately monitored. Individual islands find difficulties in providing adequate equipment, facilities and trained staff for the wide range of sensitive analyses required to adequately monitor pesticides and other types of chemical pollution. A centralized facility for the OECS region would make better use of scarce resources as long as proper arrangements

and training were provided for individual countries to prepare samples for shipment. This would also be necessary to reduce public health and plant/animal quarantine safety concerns.

7. Bibliography

- Bacon, P. *et al* (1984, *et seq.*) The national reports. Proceedings of the Western Atlantic Turtle Symposium, Costa Rica. Vol. 3. University of Miami Press, FL, USA.
- Beard, J. (1949) The natural vegetation of the Windward and Leeward Islands. Guardian Commercial Printery, Port of Spain, Trinidad.
- Bunce, Leah, (1997) Integrated Coastal Zone Management of Common Pool Resources: A case study of coral reef management in Antigua, West Indies. PhD Dissertation, Department of Environment, Duke University Marine Laboratory, 243 pp.
- CEP (1991) Country Environmental Profile: Antigua and Barbuda. Caribbean Conservation Association; 212 pp.
- CIDA - Canadian International Development Agency, (1988) First draft of a natural resources management project. St. John's, Antigua
- Fernandez, G. (1990) Report on water legislation and administration. Prepared for seminar held in St. Lucia, June 21, 1990.
- Fernandez, G., Damhaug, T., Nuttle, W. and Rodrigues, I. (1999) Chapter 5. Water Resources. In: Country case Study on: Climatic Change Impacts and Adaptations Assessment (97-2200-96-43); Antigua and Barbuda, UNEP/Ministry of Planning, GOAB, p. 130-168
- Halcrow, Sir William and Partners, (1977) An engineering study of the water resources of Antigua. Volume 1 - 4, Min. of Overseas Development, London, UK.
- Henry, F. (1990) Agricultural/forestry conservation (deforestation, wildlife, agro-chemical). Paper presented to National Workshop: Towards a strategy for integrating conservation and development. Historical, Conservation and Environmental Commission, 28-29 March, 1990, St. John's, Antigua.
- Hill, E. (1988) UNEP International Environmental Education Programme (IEEP) Country Report, Antigua/Barbuda. Presented to a sub-regional training seminar on the incorporation of environmental education for the Caribbean, Jamaica.
- Hill, I. (1966) Soil and Land Use Surveys No. 19A & 19B: Antigua and Barbuda, Regional Research Centre, UWI, St. Augustine, Trinidad.
- Horwith B. and Lindsay K. (1997). A Biodiversity Profile: Antigua, Barbuda and Redonda. Island Resources Foundation: East Caribbean Biodiversity Programme Publication # 3, 43 pp.
- Jeffrey, C. & Henry, McRonnie, (2000) Draft Antigua and Barbuda Biodiversity Strategy and Action Plan, Office of the Prime Minister, St. John's, Antigua, 54 pp.
- Lausche, B. (1986) Description of national legislation related to natural resources management (first stage analysis). OECS - Natural Resources Management Project, Castries, St. Lucia.
- Lindsay K. and Horwith B. (1997). A Vegetation Classification of Antigua, Barbuda and Redonda. Island Resources Foundation, East Caribbean Biodiversity Programme Publication #2, 61 pp.

- Martin-Kaye, P. (1959) Reports on the geology of the Leeward and British Virgin Islands.
- Multer, G. (1988) Growth rate, ultrastructure and sediment contribution of *Halimeda incrassata* and *Halimeda monile*, Nonsuch and Falmouth Bays, Antigua W.I. Coral Reefs, 6:179-186
- OAS - Organization of American States (1990). Natural resources assessment, application and projects for the agricultural sector of Antigua and Barbuda. Dept. Reg. Dev., Washington, D.C.
- Yearwood, V. (2001) Water production statistics for the year 2000, Antigua Public Utilities Authority, Water Division; Report ??