Report on

Integrating Management of Watersheds and Coastal Areas in Small Island Developing States of the Caribbean: The Barbados National Report

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EXECUTIVE SUMMARY{tc \l1 "EXECUTIVE SUMMARY}

Barbados is signatory to a number of international plans of action or declarations such as the Plan Of Action for Small Island Developing States, Barbados, 1994, San Jose Declaration, Costa Rica, 1996, Plan of Action for Sustainable Development of the Americas, Santa Cruz de la Sierra, 1996 and Agenda 21, UN Programme of Action from Rio, Brazil. The initiatives from these Plans all seek to promote the establishment, enhancement and implementation of integrated approaches to water resources and coastal area management.

For the coastal areas, this has included the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities and the International Coral Reef Initiative (ICRI). It is clear that efforts or strategies to protect the marine environment from land-based activities are directly related to watershed management strategies and the need to integrate these activities is quite evident.

In Barbados a large body of legislation and policies exist for water resources and coastal area management. However, historically sector specific approaches were used to develop the relevant legislation and policies as well as the institutional frameworks. It is therefore necessary to make adjustments, develop or enhance the legislation and policies to make it consistent with the relevant international agreements to which Barbados is a signatory and to develop the enabling institutional frameworks and capacities that will help promote and ensure co-ordination and integration between the sectors. Due to the commonality of the problems across the region, a regional approach to adjusting the legislation, policy, institutional framework and capacity building is recommended.

INTEGRATING MANAGEMENT OF WATERSHEDS AND COASTAL AREAS IN SIDS OF THE CARIBBEAN

1.0 INTRODUCTION{tc \l1 "1.0 INTRODUCTION}

It is well documented that the marine environment is the recipient of contamination from anthropogenic sources, some of which have their origin from in the hinterland. As this condition is characteristic of most small islands developing states it has been recognized that the issues of watershed management and coastal zone management are currently in need of urgent attention especially at the Caribbean regional level. The Caribbean Environmental Health Institute has been designated as the Region's lead agency for freshwater resources management. The Regional Co-ordinating Unit for the Caribbean United Nations Environment Programme has been designated the lead agency for biodiversity, and integrated coastal management. Both agencies received their designation under the Small Islands Developing States Programme of Action.

Given the interrelated nature of watershed management and integrated coastal zone management, especially since activities that occur in watersheds can have a direct impact on the coastal area, it was recognized that there is a clear need to integrate freshwater resources management and coastal area management through multisectoral planning and management of island ecosystems. To this end, the Caribbean Health Institute, UNEP CAR/RCU in collaboration with the OAS and UNDP have developed a project proposal for submission to the Global Environment Facility of the World Bank.

The objective of the project is to assist participating countries of the Caribbean Region in improving watershed and coastal zone management practices in support of sustainable development. Areas of foci in the project include coastal area management and biodiversity, tourism development protection of water supplies and control of land based sources of pollution.

The project is intended to help participating countries address some of their major environmental problems that traverse watershed and coastal areas management:

- coastal water quality issues;
- the unacceptable levels of contamination of (i) groundwater and (2) coastal water and freshwater from land based activities.
- over extraction of groundwater and the depletion of available water resources often exacerbated by seasonal tourism demands.
- the adverse effects of tourism on water supplies and aquatic resources; and
- main power limitations in terms of adequately trained experts or practitioners to address problems.

This national report is expected to assist in the development of the regional project. The national focal point for the project is the Coastal Zone Management Unit of the Ministry of Environment Energy and Natural Resources. However the Unit received considerable assistance from the Barbados Water Authority. The Coastal Zone Management Unit therefore recommends that the Barbados Water Authority be identified as the alternate agency for this project as the project will have far reaching implications at the national level for the effective implementation of integrated watershed and coastal area management.

2.0 BACKGROUND{tc \l1 "2.0 BACKGROUND}

2.1 Location{tc \l2 "2.1 Location}

Barbados situated at latitude 13°N and longitude 59°W is the most windward of the Lesser Antilles island chain. Lying some 144km east of the Caribbean chain, its nearest neighbour is St. Vincent, approximately 160Km to the west. It is also approximately 500km north of the South American mainland (Map 1). It lies within the path of the South Equatorial Current, which is the stronger and more constant of the two West setting equatorial currents - North and South. The direction of the South Equatorial Current remains constant throughout most of the year, over 75% of the time being constant during the summer months (May through August) (Archer 1976).

Barbados is a small coral limestone island, being 34km long and 23km wide and having a total area of 432km^2. Its greatest elevation is 337m. It is bounded on its eastern coast by the Atlantic Ocean and on its western coast by the Caribbean Sea (Map 2).

2.2 Geology and Physiographic Form{tc \l2 "2.2 Geology and Physiographic Form}

Barbados is predominately a coral limestone island, being covered for the most part (approximately 85%) by Pleistocene reef limestone averaging some 70m in thickness (Map 3). This limestone formation rises as a succession of terraces, slopes and scarps. On the main part of the island facing north, west and south, it rises as a series of apparently wave cut terraces. On the eastern side of the island the limestone has broken away and exposed an underlying oceanic formation of sedimentary rocks. This side of the island shows no rising terraces. (Lewis 1960, Barker and Poole 1983).

The island is a sea-mount. Its limestone formation gives the landscape a gently undulating appearance, which is interrupted by deep gullies and by a series of near-vertical cliffs, which are old coral reefs. The numerous steep gullies and ravines, with depths up to 30 metres forms the basic drainage system of the island. The gullies run down from the central highland towards the coastline.

2.3 Coastal Form{tc \l2 "2.3 Coastal Form}

The coastline is regular with no deep indentations. They are only 2 major bays on the island, Carlisle Bay, and Oistins Bay both on the south coast of the island. Barbados has approximately 92 km of coastline comprising 33 km coral sand beaches, 32 km coral sand beaches, 32 km coral limestone cliffs, 11 km sedimentary slopes, 11 km silica sand beaches and 10 km man made defenses (Cambers 1983).

The leeward side of the island (the west and south coast) possess the greatest density of residential development and these coasts also constitute the areas of tourism accommodation, supporting in excess of 149 Hotels and Apartment/Hotels.

2.4 Climate

Barbados lies within the belt of the North West Trade Winds and has a predominantly sub-humid tropical climate (James et al. 1977). Average annual temperatures range from 24 - 28°C and seasonal variations are slight. Temperatures reflect the average sea surface temperature which varies little. On average sea surface temperatures are at their lowest

between February and March (25-27°C) and highest in September and October (28-30°C) (Lewis 1960).

The main seasonal variation is determined by rainfall and the year is divided into wet and dry seasons. The trade winds blow with a high degree of constancy all year and thus offset the adverse effects of a continual high temperature and high humidity (Procter and Redfern 1984).

2.5 Rainfall{tc \l2 "2.5 Rainfall}

The rainfall of Barbados is characteristic of the other windward Caribbean islands, reflecting the cyclonal movement of the zone of convergence of the North East and North West Trade Winds. The result is the concentration of the annual rainfall in a wet season. Generally island wide rainfall results indicate a definite dry season from January to May and a rainy season from June to December.

Most of the rain occurs as showers. During the dry season showers are often light while the wet season they are mainly heavy and periodically accompanied by thunder storms. Although the rainstorms may occur as bursts, the total period of rainfall is often prolonged. It is these prolonged rainfalls within the season which produce peak runoff episodes, when the ground is often saturated (Wallace Evans 1972 cited by Procter and Redfern 1984).

Regardless of the substantial annual rainfall, most rivers in Barbados are dry due to the very permeable nature of the coral rock. Through gullies and sink-holes water finds its way into underground water reservoirs which are the only sources of potable water supply. By contrast, in the Scotland District, due to the impermeable nature of the rocks, much of the rainfall is lost by run-off to the sea.

Most of the soils in the coral region are clays. They form four (4) concentric patterns in strong association with the topography. All the soils are fertile, the least fertile being Black Soil Association on the west, south, and south-east coasts. This association, combined with the lowest rainfall zones, has become the main reservoir of land for settlement development.

2.6 Surface Drainage{tc \l2 "2.6 Surface Drainage}

Despite the substantial annual rainfall, most of the rivers in Barbados are dry due to the permeable nature of the coral rock. As a result there are no rivers which may be used as sources of potable water. For the most part the surface drainage systems of the island follows a distinct pattern consisting of a primary system of main gullies radiating outward from the highland areas of the island and a secondary system of smaller gullies and gully tributaries at approximately right angles to the primary system (Map 4). As a result of the geology of the island, gullies are absent in the southern and northeastern region of the island. This has been attributed to (1) low rainfall and (2) the prevalence of sheet water rather than stream water channel flow in these areas (Procter and Redfern 1984).

Above the 80m contour, gullies are cavernous and capable of absorbing water at very high rates. Below this elevation the gullies are neither deep nor cavernous, but frequently carry surface runoff into the lower reaches of the drainage system (Wallace Evans 1972).

Actual surface stream flows within the island are periodic and only at times of high intensity rainfall are significant volumes of water transported in them. Along the south and west coasts of the island, several of the tributary orifices have been canalized to better control the actual discharge of surface runoff during periods of peak flow. Several of these locations are the catchment areas of several interconnected gullies with a common discharge point (Map 5). At these locations a sand bar often forms across the outlet blocking the discharge water from entering the sea. This results in the accumulation of stagnant polluted water behind the sand bar. The sand bar is often breached at times of heavy rainfall thus allowing the runoff to reach the sea. The bars may sometimes be breached by mechanical methods to alleviate the problems associated with the stagnant waters (eg. stench and mosquito breeding).

2.7 Groundwater{tc \l2 "2.7 Groundwater}

This is the only source of potable drinking water on the island. Groundwater is often located in large collection areas or "reservoirs" within the aquifer. These aquifers are serviced by natural underground streams which have periodic connection to the surface via sink holes. These sink holes serve as a source of fissure recharge and probably represent the coral cap caving into cavern tunnels made by underground streams (Harris 1971 cited by Procter and Redfern 1984, BPDP 1988).

Most of the coral cap is situated above the water table and all of the coral cap is in the vadose zone. Above elevations of 60m, groundwater transmission occurs within an integrated drainage net in ground water stream channels. These underground streams may be divided into catchments based on more or less drainage nets (Procter and Redfern 1984).

Groundwater streams may be subject to pollution depending on whether the water has benefited from filtration through the vadose zone or if it has gained entry to the system via the open fissures and suck holes in the coral cap. For the most part, all ground water extraction wells are located in the sheet water zones as far inland from the coast as possible. This is because ground water quality decreases rapidly to the seaward side of supply wells and the coastline also supports the greatest density of residential and tourism facilities.

2.8 Population{tc \l2 "2.8 Population}

In 1980, the population of Barbados reached approximately 247 000 persons and the approximate population of the Greater Bridgetown area 106 500 or 43% of the national total. Beyond the Greater Bridgetown area, a continuous linear pattern of settlement extends along the west coast to Speightstown, and along the south coast to Oistins, and more recently the parish of St. Philip. The total population living in this urban belt in 1980 was approximately 152 000 or 62% of the national population (BPDP 1988). In 1990 the total resident population of Barbados had increased to approximately 257,000 with a rate of population growth of 0.1% (Barbados Economic Report 1991).

The remainder of the population is distributed in numerous tenantries and villages scattered all over the country. A major issued raised in the Physical Development Plan for Barbados (1988) is the potential pressures of suburbanization of many of the rural settlements located close to the Greater Bridgetown area, which could result in the emergence of the problematic urban - rural continuum in the settlement pattern. This is an issue which has to be carefully controlled by Government. However it is projected that there will be continued and increased population growth in the coastal belt especially between the first and second high cliffs from Speightstown, St. Peter to Long Bay, St. Philip.

At present St. Philip is the most rapidly expanding developing zone on the island, and it is projected that there will be continued development and growth not only in the St. Philip area, but also in St. Lucy, all of which will be associated with the suburbanization process. (BPDP 1988).

3. CURRENT WATERSHED/WATER RESOURCES MANAGEMENT ISSUES{tc \l1 "3. CURRENT WATERSHED/WATER RESOURCES MANAGEMENT ISSUES}

Barbados is an island approximately 430 square kilometers in size with clearly demonstrated needs for proper management of its watersheds and coastal areas as evidenced by the early (1964) enactment of the groundwater protection zoning policy. Despite the recent implementation of a brackish water reverse osmosis desalination plant, it is still entirely dependent on groundwater abstracted from an unconfined coral-rock formation that covers about 84% of the island. The coral-rock formation that constitutes the groundwater aquifer is underlain by an impervious formation of oceanic sediments comprised of clays, sand, shales and marl. These oceanic sediments are exposed in the eastern section of the island called the Scotland District, which is also an area considered not to have any economically exploitable quantities of groundwater, but has been noted to have some springs.

In should also be noted that in its bid to improve and properly manage the water resources, Barbados has already chosen to adopt an integrated water resources management approach, in line with international trends and best management practices. In addition, it is currently collaborating with the Commonwealth Science Council and World Bank through the Barbados National Council for Science and Technology on a pilot project on stakeholder participation in water resources management.

Adoption of an integrated watershed and coastal area management approach is therefore timely and would lead to greater efficiencies in management.

3.1 Freshwater Habitats and Ecosystems{tc \l2 "3.1 Freshwater Habitats and Ecosystems}

The island of Barbados' freshwater systems consist of nineteen (19) groundwater units in the coral covered section of the island (84% of the island), three major springs and a large number of small springs and rain-fed streams contained within the Scotland District on the east coast (Map 6). The Scotland District has no coral cover and is assumed not to have large quantities of groundwater.

There are no perennial and large rivers on the island, but there are a large number of deep and dry gullies, which cut into the coral rock and carry rainfall runoff to the sea during the rainy season. The biggest perennial surface water body is contained in the Graeme Hall Swamp, in the southern part of the island, which is now being developed into a privately owned bird sanctuary.

In 1964 the island was subdivided into five (5) groundwater protection zones under a Groundwater Protection Zoning Policy adopted and implemented to protect the water resources and public water supply wells (Map 7). This means that every area of land falls under some protective zone with varying degrees of restrictions on land-use practices, depending on their location and proximity to public water supply wells or areas ear marked for this purpose.

However, under this zoning system, only four of the five zones, Zones 1 to 4 have the potential to influence the groundwater quality of the public water supply wells. Zone 5 areas fall outside and downstream of the water collection areas for these wells and the restrictions on this zone relate more to coastal zone protection.

In addition, due to the unconfined nature of the aquifer system, it is vulnerable to all above ground land-use activities including housing developments and their wastewater disposal systems, the majority of which use shallow to deep soak-away wells into the coral rock.

Luckily the majority of the most densely populated areas are presently located downstream of the line of public water supply wells and the major recharge areas.

At the time of the development and implementation of the existing zoning policy, bacteriological contamination was seen as the major threat to the groundwater resources. However, recent developments in golf course and housing developments at locations further inland may increase the pollution loading due to housing developments in the upstream sections of the groundwater catchments.

Secondly, recent rainfall patterns with below long-term average rainfall conditions have resulted in reduced groundwater recharge, which could result in reduced dilution of the pollution loading and therefore negatively impact on groundwater quality. This in combination with the increase and variety of chemicals in use as a result of agricultural diversification increases the vulnerability of the groundwater to chemical contamination.

Increasing demand for land for other infrastructural developments such as for housing and golf courses, now pose a serious challenge to the maintenance of the current zoning system and restrictions.

3.2 Supply and Demand{tc \l2 "3.2 Supply and Demand}

In addition to groundwater abstractions for public, private, industrial and commercial uses the watersheds are also subjected to demands for other land uses such as housing, golf courses, agriculture, tourism and hotel developments and recreational use.

According to current information from the Barbados Water Authority (BWA), the total abstractions in 1999 and 2000 (from 21 public water supply wells and 2 spring sources) fell down to 140,909 m^3/day (31MGD) from a 1996 and 1997 high of 159,091 m^3/day (35 MGD). Other abstractions include that from privately owned and operated wells for industrial and irrigation uses. The amount licensed for private abstractions is approximately 36,364 m^3/day (8MGD). Table 1 shows a breakdown of the available water resources**.**

Table 1 – Breakdown of Available Water Resources{tc \l1 "Table 1 – Breakdown of Available Water Resources}

SOURCE	1978 STUDY				1997 STUDY	
	AVERAGE RAINFALL CONDITIONS (60")		1 IN 15 DESIGN DROUGHT YEAR		AVERAGE RAINFALL CONDITIONS (56")	
	m^3/day	(mgd)	m^3/day	(mgd)	m^3/day	(mgd)
Groundwater	205,773	(45.27)	137,182	(30.18)	202,591	(44.57)
Surface water	32,682	(7.19)	13,136	(2.89)	15,909	(3.5)
Spring water	8,182	(1.80)	5,909	(1.3)	5,455	(1.2)
Waste water*					30,018	(6.6)
Runoff	2,409	(0.53)	0.0	0.0	1,455	(0.32)
Total	249,046	(54.79)	156,227	(34.37)	225,410	(49.59)

* Potential volume of wastewater that could be available from the existing Bridgetown and proposed South and West Coast sewerage systems.

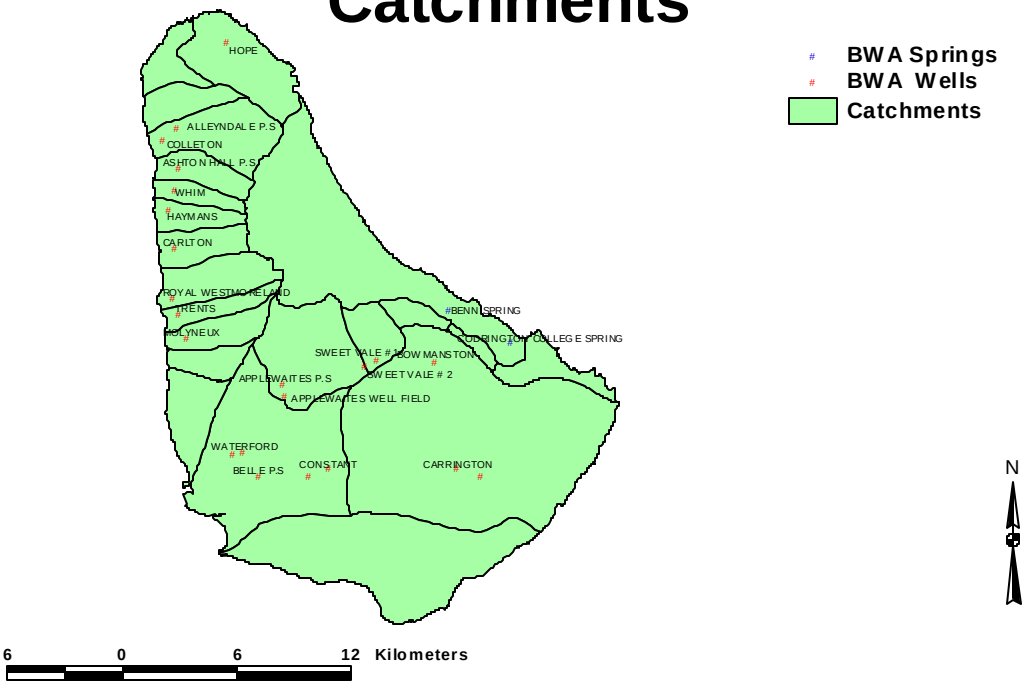
In February 2000, a 30,000 m^3/day brackish water Reverse Osmosis Desalination Plant was commissioned

and started production at half capacity to augment the public water supply and meet the needs of an economic boom and increased activity in the construction industry.

In terms of water consumption, irrigation is second only to domestic use. Current agricultural irrigation water allocation amounts to 16,200,000 m^3 per year. Without irrigation, production of food crops in Barbados is extremely dependent on rainfall, water deficits are generally experienced during the dry season resulting in low yields and occasionally crop failures. Out of the approximately 21,000 hectares in agricultural holdings, 17,000 hectares are non-irrigated and therefore rain fed. Irrigation has been forecast to increase 15 to 20% over the next 10 to 15 years if export markets can be gained and less than half if only local markets are supplied. This translates to an average increase rate of 1% annually and includes food security considerations as well as plans to diversify agricultural production and reduce dependency on sugar cane production. The table below gives a generalised land use distribution broken down into three categories.

CATEGORY	PERCENTAGE
Agriculture Total	60.3%
Natural Total	21.2%
Urban Total	18.6%

BWA Wells and Groundwater Catchments



Other major irrigation water demands are from the present three golf courses, two (2) of which are irrigated from private wells and the third (3) with treated wastewater. The total groundwater used for golf course irrigation presently amounts to 2,368 m^3/day. The amount of treated wastewater used could not be ascertained. Two other golf courses, which were previously in use, are being rebuilt. One is an eighteen-hole course and the other is being expanded from18 to 45 holes. Their water usage during construction could not be ascertained.

A number of other golf course developments have been approved and are likely to come into play in the near future. These proposals and their corresponding estimated water demands, based on average water requirement of 1,135m^3/day per 18 holes, are shown in the Table 2.

Table 2. Approved Golf Course Proposals and Related Irrigation Water Demands{tc \l1 "Table 2. Approved Golf Course Proposals and Related Irrigation Water Demands}

NAME & LOCATION	SIZE	WATER REQUIREMENT M^3/DAY
Sandy Lane, St. James	45 holes	2840
Kingsland, Christ Church	90 holes	5682
Apes Hill, St. James	18 holes	1136
Bushy Park, St. Philip	18 holes	1136
Durrants, Christ Church	18 holes	1136
Total		**11930**

The resultant increase in irrigation water demand for the golf courses, once these facilities are fully operational, would be about five (5) times that of present demand and the demand from the public water supply system would more than double.

Presently there are no special measures linked to drainage from irrigation schemes except for golf course developments where the conditions for development approval require the setting up of an Environmental Best Management Plan. A groundwater monitoring programme is included in this Plan to monitor and evaluate the impact of golf course chemical applications on the groundwater. The issue of collaboration between the Barbados Water Authority and the Ministry of Agriculture in relation to providing extension services and a public awareness and education programme to address efficient water use and agricultural chemical applications has been considered. However, not much progress has been made in this regard.

Some of the irrigation wells end up using brackish water especially during the dry season, however the impact on soil salinity has not been formally assessed. A cursory look at the areas in question seems to suggest that there has been no significant noticeable impact on the crops that are generally grown in these fields. As part of the WRMWLS, 1997, six agricultural plots were fitted with suction lysimeters below the root zone, as part of an eighteen-month pilot study to evaluate the impact of agricultural chemical applications on the groundwater. This has provided some preliminary information on potential leaching of agricultural chemicals through the soil cover to the top of the coral rock for various soil types and crops. Attenuation through the coral rock still needs to be determined. Based on the island-wide water quality monitoring programme results, it is known that agricultural chemicals are impacting the groundwater quality.

Only three water rate categories are considered in the tariff structure (Table 3), Domestic or Residential customers (who are broken down into metered and unmetered or fixed rate), Commercial Customers and Cruise Ship Customers. For the fixed rate customers their charges are based on the total of Net Annual Value of their property plus the number of water fixtures on the property.

Table 3 - Water Rate Structure{tc \l1 "Table 3 - Water Rate Structure}

WATER RATES	
Basis	Monthly Charge/Rate
UNMETERED CUSTOMERS	BD$13 to BD$54
METERED RATES	(minimum charge BD$20.00 per month)
0 to 34 m^3 per month	BD$1.50 per m^3
Over 34 m^3 per month	BD$2.12 per m^3
Commercial	BD$2.12 per m^3
Ships*	BD$3.50 per m^3

*Price at which water is sold to the Port Authority.

It is not clear what the tariffs are intended to recover, however previous reviews suggest that they seem to be aimed at recovering only the operating and maintenance costs.

Existing policy and water rate structures are not conducive to the promotion and implementation of water conservation practices. For example due to the use of a minimum charge for metered customers, customers falling in this category end up paying for water that they did not use. For the fixed rate (un-metered) customers there is again no incentive to use less water since they pay the same amount irrespective of volume used. In addition to the adoption of universal metering programme, a rising block tariff structure has been recommended with no minimum charge. This it is hoped will help induce more efficient water use.

A number of hotels have applied for and are utilising treated wastewater for irrigating their lawns and plants as a way of reducing their freshwater demands. Reuse is therefore a viable option that has been shown to be acceptable to the public for uses such as groundwater recharge and irrigation, based on a survey conducted under the Water Resources Management and Water Loss Studies, 1997.

Based on the Water Resources Management and Water Loss Studies (WRMWLS), 1997, the economic value of water for a number of different uses was calculated to be:

Category Of Use - Value In BD$/$M^3$	
Domestic (including commercial & institutional)	7.60
Hotel (tourism)	12.00
Agricultural Irrigation	1.50
Golf-course irrigation	10.00
Industry	0.00

These figures seem to suggest that the present water rates do not reflect the economic value of water.

3.3 Groundwater vis-à-vis Surface Water{tc \l2 "3.3 Groundwater vis-à-vis Surface Water}

Based on current groundwater abstraction estimates, these levels either equal or exceed the developable and sustainable groundwater yields for most of the groundwater units. This demand cannot be met in the design drought of 1 in 15 or 1 in 20 year return interval, adopted by the 1978 and 1997 Water Resources Studies respectively.

Present public water supply amounts to 31.4 MGD from groundwater wells, 0.6 MGD from two (2) spring sources and 3 to 4 MGD from the brackish water Reverse Osmosis Desalination Plant. Surface water use is limited to a small number of lined ponds that collect road runoff and other surface water storage schemes constructed in gullies for irrigation water use. Due to land slippage and water quality problems and relatively high per cubic meter production costs, surface water contained in the Scotland District has yet to be exploited, but is now being considered for small scale agricultural projects by the Ministry of Agriculture.

As a result of the topography and mode of occurrence of the groundwater, approximately 90% of the public water supply is from wells located in “sheetwater zone” or freshwater lens area where the freshwater floats on top of salt-water and 64% of the private wells are located in this same area. Whereas all public water supply wells are monitored for salinity, most privately operated wells are not. The aquifer is therefore quite vulnerable to salt-water intrusion generally through upconing below the pumped wells as experienced by the rising salinity levels during the 1993 and 1994 drought years.

Fortunately due to the high transmissivity values associated with this coral rock, most upcoming problems are easily addressed by well design and management practices such as:

1. Resting the wells or a reduction in pumping for periods as short as twenty-four hours.
2. Continuos monitoring of salinity and groundwater levels at the BWA wells and some private wells. For some of the most sensitive wells, the monitoring frequency is reduced from monthly to daily during the dry season. However, greater control needs to be exercised in relation to salinity and abstraction levels as provided for under the BWA Act, 1980. And the Underground Water Control Act
3. Control of groundwater abstractions through a licensing requirement and provision of abstraction limits based on water balances for each groundwater unit and available water resources.
4. Controlled positioning of the pumps relative to saltwater/freshwater interface.
5. Construction of horizontal adits (7 ft high, 4 ft wide, 4 ft in water and 100 ft long) at the bottom of the vertical shaft (6 ft to 10ft square), perpendicular to flow direction, to help increase yield without an attendant higher draw-down. Greater surface area is obtained through the use of adits without deepening the vertical well shaft and getting closer to saltwater/freshwater interface.

With the acquisition of a new BWA rotary drilling rig, plans are in place to set up another salinity profiling monitoring network and the setting up of a unit to carry out this work and monitor the private wells.

Current private well groundwater abstraction license conditions, apart from setting a limit on the volume to be abstracted over a twenty-four-hour period, do not provide anything else to induce efficient water use. To this end recommendations have been made and approved by Government, for the BWA to develop and charge a license fee as well as a charge based on the volume of water abstracted and to ensure that all abstractions are metered. This in addition to better enforcement of the license conditions, should help induce efficient water use practices as well as reduce the risk of saltwater intrusion due to private well over abstraction.

The groundwater protection zoning policy provides source protection, whereas saltwater intrusion is

controlled through appropriate well design and management practices outlined above. Due to the nature of the aquifer material, land subsidence is not an issue except when caves are encountered.

The BWA does not collect any sea level rise data as this is not their responsibility. A national water conservation plan was developed under the WRMWLS, but the major emphasis is on public education campaign and retrofitting. However, sector specific programmes are undertaken by BWA personnel.

3.4 Land Use{tc \l2 "3.4 Land Use}

The current land-use policy is embedded in the Draft Revised Physical Development Plan, which is currently under review through public consultations before being adopted to replace the previous plan. The groundwater protection zones and associated land-use restrictions are incorporated and enforced through the use of this Plan and the Town and Country Office Development Order under which it falls.

The conflicts that arise in relation to land-use in the watersheds basically relate to the restrictions placed on the various groundwater protection zones. See Table 4 for a summary of the applicable conditions for each zone. For example, no new structures including houses are allowed to be constructed in Zone 1 areas. The percentage amounts of land contained in Zones 1 to 5 are, 9.37%, 13.43%, 15.21%, 31.71% and 30.28% respectively.

Table 4: Features of Development Control Zones{tc \l1 "Table 4: Features of Development Control Zones}

Zone	Definition of Outer Boundary	Maximum depth of soak-away pits	Domestic Control Restrictions	Industrial Control Restrictions
1	300 day travel time	None allowed	No new housing or water connections. No changes to existing wastewater disposal except when Water Authority secures improvements.	No new industrial development.
2	600 day travel time	6.5m	Septic tank of approved design, discharge to soak-a-way pits. Separate soak-a-way pits for toilet effluent and other domestic wastewater. No storm runoff to sewage soak-a-way pit. No new petrol fuel or oil tanks.	All liquid industrial wastes to be dealt with as specified by the Water Authority.
3	5-6 year travel time	13m	As above for domestic wastewater. Petrol fuel or oil tanks to approved leak proof design.	Maximum soak-a-way pit depths as for domestic wastes.
4	Extends to all high land	No limit	No restrictions on domestic wastewater disposal. Petrol fuel or oil tanks to approved leak proof design.	
5	Coastline	No limit	No restrictions on domestic wastewater disposal. Siting of new fuel storage of Water Authority.	

A number of government departments now have GIS setups with a number of layers developed to suit their interests. These include the BWA, Town and Country Planning Office, Ministry of the Environment, Energy and Natural Resources and the Ministry of Public Works and Transport. Whereas the first three all use ArcView Software, the Ministry of Public Works and Transport, uses MapInfo software.

The Draft Physical Development Plan and the Groundwater Protection Zones are already contained on the existing GIS layers.

Floods have had a greater impact on watershed management than droughts due to the potential groundwater pollution that may result from increased agricultural runoff, the clogging up of recharge and drainage wells due to increased soil erosion and/or solid waste and due to land slippage problems.

Rainfall runoff measurements have generally only been done as part of short-term projects. Flood records are therefore generally limited to flood heights with no corresponding discharge measurements or on some estimates derived from rainfall records. Drought records however can easily be derived from the available rainfall records, which date back to 1847.

The government's Central Emergency Relief Organisation (CERO) coordinates the disaster preparedness for floods and droughts plans and response activities, utilising a number of government agencies, NGOs and individual volunteers.

3.5 Climate Change and Natural Disaster{tc \l2 "3.5 Climate Change and Natural Disaster}

There has been no observed impact of sea level rise or extreme weather conditions on the watersheds. However, Barbados, Guyana and Grenada are participating in a three-month (July to September, 2000) pilot study sponsored by Caribbean Plan for Adaptation to Climate Change (CPACC), which is intended to analyse the potential impact of various climate change scenarios including sea level rise, on the water resources.

The BWA has an Emergency and Drought Preparedness Plan as well as a Hurricane Preparedness Plan and collaborates with the Central Emergency Relief Organisation (CERO) and other agencies, if and when required.

3.6 Transboundary Threats{tc \l2 "3.6 Transboundary Threats}

Due to its isolation as an island, there are no transboundary threats to its freshwater resources. However, global climate change impacts may be considered transboundary threats.

3.7 Pollution{tc \l2 "3.7 Pollution}

Due to the karstic nature of the hydrogeology and the fact that the aquifer is unconfined the groundwater is quite vulnerable to land-based pollution. Watershed management has therefore required that some restrictions and controls be placed on some land-use activities. This has been achieved through the implementation of the groundwater zoning policy and through the use of the Physical Development Plan, which makes the zoning policy enforceable.

The main sources of land-based pollution are agricultural runoff and leachate, leachate from landfill sites, illegally dumped solid waste and wastewater from housing developments.

Deforestation is not a very apparent problem in Barbados, since most of the deforested land was covered by sugar cane fields. Changes in cultivation practices from the use of “cane holes”, shallow circular holes in which the cane was planted and the planting of rows of grass of or peas around the sugar cane fields to control soil erosion, to mechanisation and abandonment of these old practices, has resulted in increased soil erosion problem. This in turn has resulted in increased sedimentation of recharge and drainage wells and possibly reduced groundwater recharge. As a further consequence of the erosion of this thin layer of soil cover, there is also a reduction in the pollution attenuation capacity of the watershed, with potential negative impact on groundwater quality.

3.8 Tourism{tc \l2 "3.8 Tourism}

The major tourism concerns related to watershed management at the moment are the potential impact of golf course sports tourism development projects on groundwater recharge and quality due to construction of hard surfaces, chemical applications, liquid and solid waste disposal and the increased demand on the limited water resources.

In addition, currently the majority of the tourism infrastructure is located downstream of the line of the public water supply wells on the West and South Coasts. Due to the congestion and higher costs of lands, there has been a trend to move inland and upstream of the public water supply wells. This will pose a major concern to watershed management of the upstream recharge areas. Eco-tourism project developments within the watersheds will also need to be closely monitored.

3.9 Health{tc \l2 "3.9 Health}

The major health concerns related to watershed management are the control of activities that may impact on water quality. To this end a national water quality monitoring programme is in place to monitor the bacteriological and chemical quality of the water on a monthly basis. This is carried out by the BWA and the Environmental Engineering Division (EED) of the Ministry of Health in collaboration with the Coastal Zone Management Unit and the Ministry of Agriculture. It was recently agreed between the BWA and MOH to expand the monitoring programme to include a check for the possible presence of emerging pathogens such as Cryptosporiduim and Giardia.

Since the implementation of the groundwater zoning policy in 1964, there have been no major reported incidences of water-borne or water-related diseases. Current drinking water quality meets the World Health Organisation (WHO) Drinking Water Guidelines.

3.10 Data, Information Management and Research{tc \l2 "3.10 Data, Information Management and Research}

Present estimates of the water resources situation are greatly hampered by the amount, type and quality of data and information available due to lack of appropriate data collection networks, quality control and poor allocation of funds and human resources. Currently there are very limited coordinated programmes to collect and analyse this data and information in-house, on an on-going basis.

The BWA is currently collecting rainfall data collected mostly by volunteers at plantation houses, groundwater levels, salinity profiles and water quality data and monitoring of infringements on zone restrictions. Other data or information available that is relevant to watershed management is location of wells, groundwater catchment boundaries, potential yield from each groundwater unit, groundwater protection zone boundaries and potential contaminant source locations. The other agencies involved are the Ministry of Agriculture and Ministry of Health whose roles are explained in another section of the paper.

The available equipment is limited to transducers, data loggers, and groundwater level measuring tapes and rain gauges. No external data collection support is currently being utilised. A variety of technologies have currently been introduced and are being utilised to provide decision-support information for water resources management. These include the use of:

- Geographical Information System (GIS) – ArcCad and ArcView
- Computer Modelling of groundwater resources – (GMS Software package)
- Digital on-site water quality data processing equipment.

The areas of resource assessment, research, training and public education have generally been neglected and most of the resource assessment has been done through the use of outside consultants and at very long intervals of 15 to 20 years.

Additional human and financial resources need to be provided in order to improve watershed management. Currently issues related to maintenance of the public water supply network overshadow this aspect of the responsibilities.

Some major areas of research needs are:

- Modelling of the groundwater systems,

- determination of hydrogeological parameters,
- impact of brackish water abstractions on freshwater lenses,
- impact of agriculture and other land uses on water quality,
- identification and quantification of spring sources,
- assessment of effectiveness of zoning policy and restrictions,
- water quality trends
- evaluation of potential impact of climate change on watersheds and water resources

3.11 Stakeholder Participation/Awareness and Education{tc \l2 "3.11 Stakeholder Participation/Awareness and Education}

A number of approaches and activities have been undertaken and are ongoing in relation to water resource management. These activities have included:

i Ongoing Water Conservation messages on television as well as all print media.

ii National Consultation Meetings organised by the National Commission for Sustainable Development on Sustainable Water Resources Development and Management

iii Presentations to specific target groups by BWA personnel in (i.e. primary and secondary schools, church groups, social clubs, BHTA, Planning & Priorities Committee – a sub-committee of cabinet, teachers, Union Members etc.)

iv Use of Skits on TV

v Distribution of 30,000 low water use fixtures (showerheads and Kitchen tap aerators) to fully paid-up BWA customers.

vi Water Conservation Projects for specific targets groups;

- Retrofitting of primary school water fixtures using private sector participation (donation of fixtures)
- Setting up of project in hotel sector with demonstration schemes utilising participating hotels that have agreed to retrofit certain fixtures as their contribution.

vii Tours of BWA's facilities after a one to two-hour presentation and question and answer session.

viii BWA personnel participation on various discussion panels

ix Participation in radio call-in programmes

x Town Hall Meetings

However, there has been no specific survey carried out to assess the success or failure of these activities. It is very clear though, that the level of awareness has risen based on the increased number of letters and articles on water related issues, in the newspapers and discussions on call-in programmes.

There are no specific programmes aimed at facilitating the participation of women in water resource management. In addition, there has been very little public participation in the decision making process, but their input has been sought during the conduct of studies and recent (1997) development of the Draft Policy Framework for Water Resources Development and Management.

3.12 Institutional Frameworks{tc \l2 "3.12 Institutional Frameworks}

Through the Underground Water Control Act, CAP 283, 1953 and the Barbados Water Authority Act CAP 274A, 1980, the Barbados Water Authority (BWA), a statutory body falling under the Ministry of Public Works, Transport and Housing, has been given the responsibility for water resources management in Barbados, for all the water resources except for two spring sources which are controlled by the Three Houses Spring Act, 1713 and Porey Spring Act, 1864 respectively.

The BWA's Act empowers the Authority to provide water and sewerage services for the entire island as well as the jurisdiction to make regulations, educate and advise the public on water related issues and to manage, allocate and monitor the water resources of Barbados with a view to ensuring their best development, utilization, conservation and protection in the public interest. The BWA is also required to obtain and analyse information and maintain records of the total water resources of Barbados as well as conduct research programmes and prepare statistics for its purposes.

No clear provision is made in either of the Spring Acts for managing these water resources. Provision has only been made for collecting and utilising the water. Porey Spring has since fallen into a state of disrepair and reduced yield and the Three Houses Spring has experienced conflicts between landowners on the damming of the rivulet.

Recommendations were recently (1997) made to the Government of Barbados for the repeal of the two Spring Acts and incorporation of the same under the BWA Management and Act.

It is therefore, clear from the four (4) Acts that the Barbados Water Authority has the major responsibilities for water resource management in areas that include policy formulation, research, treatment, distribution (production), wastewater, source protection and resource assessment. However, four (4) other agencies have major roles that can impact on groundwater use, monitoring and control.

The Ministry of Agriculture and Rural Development has a Land and Water Use Unit which is responsible for developing and delivering water for irrigation and through the Barbados Agricultural Development and Marketing Corporation (BADMC) operates a number of wells for this purpose. This unit previously also carried out the hydrological investigations for siting new wells and during and after the 1978 Water Resources Study, was responsible for salinity profiling and monitoring.

The Environmental Engineering Division (EED) of the Ministry of Health (MOH) is responsible for the monitoring and control of conditions likely to affect the quality of land, air, water and general health and environmental well-being of the inhabitants of Barbados. They are also required to review all development applications to ensure compliance with the groundwater protection zoning policy and currently carry out a monthly monitoring programme of BWA and some private wells for chemical and bacteriological contaminants.

The Town and Country Planning Office oversees the enforcement of the zoning policy, which is carried out through the use of the Development Order, which states that exemptions from development control do not apply to Zone 1.

The Ministry of the Environment, Energy and Natural Resources is currently attempting to create a water resources unit under its umbrella. Its mandate is not yet determined, but it predicated on the premise that the present arrangement whereby the Barbados Water Authority has responsibility for both regulating and licensing of groundwater abstractions and supplying water raises potential areas of conflict.

A substantial body of applicable laws and policies exists to address groundwater development and management in Barbados. However, presently the major policy framework is contained in the Draft Policy Framework for Water Resources Development in Barbados, which was approved by the Government of Barbados, in 1997. This was prepared by a team of technocrats appointed by the Planning and Priorities Committee (PPC), a sub-committee of Cabinet.

Whereas the BWA finances the majority of its capital works programmes, other major projects are financed by loans secured on BWA's behalf by government from international funding agencies. It was not possible to ascertain the investments made in the sector.

It is very difficult to assess the level of skills available in water resources management in the country due to the fact that the majority of major water resources management activities are all carried out by the Barbados Water Authority and there is no inventory of available expertise nationally. The BWA currently has on staff, one water resources engineer, one water pollution control officer, one civil engineer, two engineering assistants and one geologist who is now doing his MSc in hydrogeology, who are directly involved in water resources management. Over the years, a number of local consulting firms have collaborated with foreign companies in carrying out a number of water resource projects.

However, it is generally agreed that there is a lack of adequately trained manpower both within the Barbados Water Authority and other agencies due to inadequate remuneration and failure to attract and retain qualified staff and lack of structured training programme

4.0 CURRENT COASTAL MANAGEMENT ISSUES{tc \l1 "4.0 CURRENT COASTAL MANAGEMENT ISSUES}

Coastal area management has been effectively practised since the mid 1980's when Barbados embarked on its coastal conservation programme. From its inception the programme has successfully and successively expanded to incorporate new trends in the field of Integrated Coastal Management. This has been culminated to date in the management plan for the shoreline and a policy framework for integrated coastal zone management.

In order to improve the management of the island's coastal resources, Barbados will initiate an Investment Phase Program as part of its coastal conservation program. The integrated coastal zone management approach will utilize the best management practices option available to ensure the maximization of limited financial and human resources to ensure the highest quality end product. Further, stakeholder participation through demonstration projects and the use of the round table consultative approach will also be introduced as a way of ensuring that the public understand that their involvement contributes to the decision making process in coastal management.

4.1 Coastal Habitats and Ecosystems of Barbados{tc \l2 "4.1 Coastal Habitats and Ecosystems of Barbados}

Nearshore tropical marine communities are of great socio-economic and biological importance being essential to the maintenance of the coastal ecosystem. Barbados has the following types of nearshore communities: coral reefs, coral rubble habitat, seagrass beds and mangroves.

· **Coral Reef System**

The coral reef systems of Barbados are divided into (a) fringe (b) patch and (c) bank reefs. These reef communities are important for their direct and indirect role in supporting the commercial fisheries of the island, for contributing to coastal biodiversity and providing critical habitats for endangered marine species (eg the hawks bill turtle) for the production of beach sand, for coastal protection (by acting as natural breakwaters against incoming wave energy), for aesthetics and recreation (contributing to the quality of life for locals and providing tourism attractions for visitors) and for education and research.

(a) Fringe reefs are found predominantly along the west coast of the island. They extend from 0m to 200m from the shoreline and found on headlands being separated from each other by sandy bays. Given their proximity to the shoreline they are most susceptible to anthropogenic sources of pollution and other impacts.

(b) Patch reefs are reef systems which are found detached from the shore in a variety of depth ranging from 3m to 40m. They are irregular in shape, size and species dominance. These reef types are found around the entire island but predominantly on the west, south, southeast and north coasts. On the west coast they occur in the shallow areas and bays between the shore and the fringe reefs, or between the fringe and bank reefs.

(c) Bank reefs occur parallel to and separated from the shoreline. They are found at a distance of 500m to 1200m from the shoreline in deep water with the crest of the reef ranging from 15m to 30m below the water surface (along the west and south coasts). In some instances the reef crest occurs in much shallower water with the top of the reef at or near the surface thereby creating a wave break. This latter condition results in the reef being termed a bank barrier reef. This reef structure is found on the south east coast and southern sections of the east coast of the island.

· **Coral rubble habitat**

Coral rubble is an erosive product of the coral reef. The habitat originates after high energy wave events have been experienced on a shoreline. The high wave energy causes reef damage with the calcium carbonate fragments of varying size being broken from the spur areas of the reef, and transported into the nearshore and beach areas. It is deposited in these shallow areas and eventually become partially buried in sand. Its rugose nature allows the area to allow for attachment and colonization by various marine invertebrates (sponges, soft corals, tunicates, sedentary polychaetes, anemones), algae (coralline turf and macro algae) and sea grasses. The rubble habitat is also as a nursery and shelter area for most juvenile marine organism including important reef fish, gastropods, molluscs, and sea urchins. The primary role of these are is to act as a first settlement and nursery areas providing a micro shelter for the early juvenile stages of most commercially important marine species. Coral rubble habitats are found primarily along the south coast of the island.

· **Sea grasses**

Sea grasses ecosystem are important for their direct and indirect role in supporting commercial fisheries, for contributing to coastal biodiversity and providing critical habitats for the endangered Hawksbill turtle. They also have an important role in coastal protection by stabilizing nearshore sediments. They are frequently found in depths ranging from 0.5m to 4m depth.

Although once prevalent along many sections of the Barbados coastline, there are only found in isolated locations at present, mainly along the south and east coast of the island. Several of the locations where the seagrasses are found are associated with coral rubble habitat.

· **Mangroves**

Mangrove areas are very limited in Barbados, with the total area of cover being less than 20 ha. The largest mangrove stand on the island is located at the Graeme Hall Swamp on the south coast. It is land locked with housing developments surrounding it, with its seaward frontage cut off by the major coastal highway and a large beach. The remainder of the other mangrove stands are located mainly on the west coast of the island, being associated with the seaward edges of water courses. The water course only flow seasonally and thus for the greater part of the year their egress points to the sea are blocked by sand bars which provides continuous communication with adjacent beaches. The effect of the sand bar results in the watercourse mouth acting as a retention area for ponded surface water runoff and groundwater feeding into the area. There is little continuous direct communication with the sea at these location.

The mangroves provide nesting and roosting locations for large colonies of cattle egrets and the large mangrove site on the south coast is used annually by migratory birds on their migration flights. The predominant mangrove species to be found on the island are the Red and to a lesser extent White mangroves. These areas are not exploited commercially, and neither are the fish and other invertebrates found in these areas.

4.1.1 Major threats to the management of these coastal habitats/ecosystems{tc \l3 "4.1.1 Major threats to the management of these coastal habitats/ecosystems}

· **Coral Reefs**

The main causes of degradation affecting coral reefs in Barbados arise mainly from deteriorating coastal water quality and physical damage. Coastal water quality is integral to the health and viability of a coral reef system. As reefs are normally found in oligotraphic water, they are highly susceptible to change in water quality such as eutrophication, sediment load, turbidity temperature, salinity and toxic chemical load.

(i) Sedimentation

Sedimentation and the effects of suspended particulate matter result principally from terrestrial runoff entering the coastal environment via water course, conducts, drain and terrestrial erosion. The sediments found in suspension in the water column, settle out onto the nearshore substrate and can thus occlude light and settle onto any ecosystems found in the zone of influence. The settled out sediment can be naturally resuspended during periods of high wave energy.

Anthropogenic sources of sedimentation in Barbados include: terrestrial runoff, industrial and domestic sewage effluent discharge, coastal construction, dredging and land reclamation. The effects of sedimentation are however more frequently associated with surface water discharge and the effects of soil erosion resulting from poor agricultural practices.

The resulting impact of excessive sediment load on coral reef systems is that it can significantly affect the structure and formation of the ecosystems by altering both physical and biological processes occurring in the ecosystems. This arises as a result of the high level of suspended particulate matter increasing the turbidity of the water and scattering transmitted light through the water column, reducing both the quality and quantity of light reaching the reef. This results in decreased photosynthetic activity by turf algae and the symbiotic zooxanthellae of hard corals, soft coral and sponges, contributing to a reduction in the level of primary production and calcification rates in the reef community.

(ii) Eutrophication

Eutrophication refers to elevated levels of nutrient within the water column. The nutrients of priority concern are nitrates and phosphates.

Nitrates gain access to the marine environment naturally from terrestrial runoff and biological activity. The anthropogenic activities contributing nutrient enrichment in Barbados include groundwater discharge (groundwater seepage occurs to varying degrees along the entire coastline). The coastal groundwater is rich in nutrients especially nitrates as a result of a higher density of coastal properties using suck wells as well as septic tanks with soakaways as the only means of sewage disposal, terrestrial runoff from agricultural areas, the discharge of domestic sewage effluent, and surface water runoff from storm water drains and watercourses.

The direct impact of eutrophication in reef areas is best exhibited by increased phytoplankton grown which increases the primary productivity of the water column. This results in the proliferation of benthic algae which derive the majority of their nutrient requirements from the water columns.

(iii) Temperature and Salinity

Water temperature increases above normal may occur naturally in shallow nearshore areas during unusually low tides or low water circulation periods. In Barbados there is only one source of thermal pollution, the power generating plant located at Spring Garden, St. Michael. The power plant relies on fresh to brackish water to cool its generators and then releases its heated effluent into the nearshore environment where it is located. Increases in temperature can have catastrophic effects on marine habitat, as many of the organisms found there live only a few degrees below their upper lethal limit.

Elevated temperatures together with other compounded factors could also contribute to episodes of coral bleaching. Bleaching occurs when the endosymbolic zooxanthellae are lost from the corals. This results in inadequate nutrition and cessation of calcification and is potentially lethal to corals.

Fluctuation in salinity are known to occur around the coastline from several sources, (eg movement of the freshwater discharged from the Amazon and Orinoco rivers through Caribbean Region, rain water runoff, freshwater discharges from industries and wastewater treatment facilities).

(iv) Physical Drainage

Direct physical damage to coral reef communities frequently result from natural events mainly in the form of storm waves or from anthropogenic activity eg marine construction, marine dredging, intensive recreational use and boat anchoring. In the latter two (2) instances it has been observed that there is considerable localized damage being experienced at locations frequented by dive boats and pleasure crafts (such at catamarans and other coastal cruisers), as these areas are often visited daily by recreationers, and comprise some of the most popular sites to be visit routinely. It is also evident that as intensified recreational use of the coastal areas continue there will be an ever increasing threat of reef deterioration.

· **Seagrasses**

Seagrasses are susceptible to several of the same factor that lead to the deterioration of coral reefs. This is principally as a result of their nearshore location and the types of coastal activities that occur in the nearshore area. Seagrasses in Barbados are susceptible to changes in water quality such as eutrophication, sedimentation and physical damage.

(1) Sedimentation

The sources of sedimentation were identified previously. The impact of sedimentation is simular to those experience on the coral reef i.e. the effects of physical smothering, reduced light penetration resulting from high sediment load and oxygen depletion in cases where sediments high in organic content are experienced.

(ii) Eutrophication

Nutrient enrichment stimulates phytoplankton blooms and the growth of epiphytic algae in and on the seagrass beds. This leads to reduced photosynthesis. This combined with the rapid development of loose filamention algae results in the reduction of the seagrass bed size.

(iii) Physical Damage

Physical damage to seagrass beds can occur as a result of marine construction and dredging, recreational use and physical exposure. In some cases the damage experienced contributes to the demise of the seagrass ecosystem with slow recovery following. As a result of physical damage, virtually all of the seagrass beds once found on the West Coast of the island have been lost.

· **Mangroves**

In Barbados the greatest management threat to mangroves has been physical damage as a result of construction, land reclamation, dredging and eutrophication. Several of the locations where mangroves once thrived along watercourses have been lost through the canalization and concreting of these areas. Also as a result of encroaching development many of the areas have been filled in and built on.

· **Marine Protected Areas**

There is one marine protected area in Barbados - Folkestone Marine Park and Reserve in Folkestone, St. James. The park is located approximately 1 km north of Holetown. It is approximately two miles long and 800 m wide. It includes both a terrestrial park with interpretive centre and a marine reserve which has been divided into four (4) areas with three (3 activity zones, 2 water sports, 1 research, 1 recreation).

The reserve contains four (4) well developed fringe reefs, several patch reefs and offshore bank reefs. The fringe reefs within the reserve have shown progressive signs of deterioration between 1982 and 1992, however between 1992 and 1997 there has been a noticeable improvement in the reef health there.

Management of the Folkestone Marine Park has from its inception been the responsibility of the National Conservation Commission. This statutory agency of Government is legally responsible for maintenance of parks and beaches, and the management of marine protected areas. At present the significant threats to the marine reserve include:

(a) Poor water quality as a result of having the reserve located in an area which receives significant fresh water loading from two of the largest watercourses on the island, that discharge in the Holetown area;

(b) Reduced habitat quality as a result of the cumulative effects of poor water quality and sedimentation;

(c) historical over fishing experienced along the entire West Coast. The original intention of the protected area was to provide a safe haven for fish to develop and allow for out migration from the area as they matured. While this has been effective to a large extent, poaching in the reserve is still a common occurrence;

(d) human use of the area may be separated into the following:

(1) **Fisheries**

The Folkestone area is surrounded by communities, which perform three (3) types of fishing - coastal pelagic, reef and pelagic fishing. The coastal pelagic fishery uses cast nets and seine nets in fish capture. This is often the principle method in which "bait fish" are caught for use in other fisheries.

The reef fishery is a multi species fishery using fish pots (traps), hook and line, or spear guns in fish capture. This form of fishing is illegal in the reserve, however to avoid high incidents of confrontation some fishing goes unreported. One of the main reason for this, is that there is confusion over where the seaward boundaries of the reserve are located, and conflicts frequently arise when fishermen claimed to be fishing next to or outside the reserve boundary and the enforcement agencies maintain they are fishing in the reserve area.

There is an increasing conflict developing between pot fishermen and divers. It has been reported to the Fisheries Division of the Ministry of Agriculture and Rural Development that divers are damaging fish pots, releasing catches and relocating pots to deep water thus making them difficult to retrieve.

The offshore pelagic fishery does not operate from within the reserve, however there are landing sites for this fishery within 3 km of the reserve to the north and south of it.

(2) **Recreation**

The park area is used heavily for nearshore recreation by cruising catamarans, party cruisers, scuba divers, snorkellers and glass bottom boats to list a few. There are sunken features in the area which are used mainly for snorkellers while divers use the bank reef and other deep water areas in and around the park.

Recreation is concentrated in the recreation and water sports zone of the park. The water sports zones cater to large and small boats, jet skis, and other fast speed water craft (banana rides, para sailing, and water skiing). The recreation zone caters for swimming, snorkelling, diving and semi submersible rides.

(3) **Scientific uses**

This section or area of the reserve is used to conduct scientific research. The reefs in this area have had extensive research performed on them since the 1950's as it coincides with the location of the Bellairs Research Institute of McGill University. This institute is a Tropical Marine Research Field Station for McGill University, however over the years it has also been used by the UWI, and other international universities.

(4) **User Conflicts**

Based on the foregoing it is clear that one of the greatest management threats to this location is the presence of a variety of stakeholders, and users, all competing for access to and use of the same limited resources in a confined space along the shoreline. Conflicts are here not only as a result of differences in perceptions and attitudes among the users, but also as a result of conflict between users, who negatively affect the environment, and those who require a certain level of environmental quality to pursue their activity.

User conflict issues in the reserve include but are not limited to the following:

- near miss accidents by jet ski users due to inadequate boundary delineation;
- harassment of tourists by beach vendors and jet ski operators;
- stress to flora and fauna from touching and holding by snorkellers, effluent disposal, and surface water discharges;
- noise pollution from party cruisers being disruptive to area residents;
- development of hotel swim areas and their exclusionary perception;
- fishermen and diver conflict over pot fishing.

The marine reserve has its own clearly defined legislation. However the current staffing of the reserve is in adequate to competently handle the daily requirements of managing a marine and terrestrial park. While attempts have been made in the past and continue to be made to effectively deliver on the management of the marine aspect of the park, the NCC has continued to focus solely on the management of terrestrial aspects of the park.

A study has been recently completed (February 2000) on the need to enhance the Folkestone Park and several recommendations have been presented for its improved management.

4.2 Living and non living resource exploitation{tc \l2 "4.2 Living and non living resource exploitation}

4.2.1 Living resource exploitation{tc \l2 "4.2.1 Living resource exploitation}

Although coastal ecosystems can be divided into habitat types for the purpose of description, management and conservation initiatives will have to take account of the strong interdependencies, which are known to exist among the habitats.

· **Coastal fishery resources**

In Barbados the majority of the fish landings are from offshore. On average only 15 -20% of the

recorded fish landings are taken between the shoreline and the bottom of the shelf slope. However the coastal system plays a much larger part in the total fishery than can be discerned from its small percentage contribution to the industry. (Fisheries Division 1997)

The coastal fishery of Barbados include the following:

(i) **Sea Urchin (*Tripneustes spp.*)**

The white sea urchin was commonly fished by divers on the north, east and southeast coasts. It is a seasonal fishery having a closed season from January to August. The urchin inhabits sea grass areas and low algae where there is little cover, thus making them easy to exploit. As a result of their easy of exploitation and loss of habitat the species has suffered the effects of overfishing. There is currently a three year moratorium on the harvesting of sea urchins in Barbados. It is hoped that the moratorium will allow for the adequate recruitment of the fishery and the replenishment of the stock.

(ii) **Lobster (*Panulirus spp.*)**

Lobsters are harvested mainly on the north and east coast and to a lesser extent on the southeast coast. There is a little information on the fishery as it is not performed for large scale commercial purposes. Two species are commonly fished (*P. argus* and *P. guttatus*). The demand for lobster is met mainly through the importation of lobsters from other Caribbean islands (mainly St. Vincent and the Grenadines).

(iii) **Fish**

The coastal catch is comprised of a large number of species and is taken by cast netting, trapping, hand-lining, saining and spear fishing.

The fishery is comprised of three types (a) the shallow reef fishery (b) the deep slope fishery and (c) the coastal pelagic fishery. The shallow reef fishery is most intense during the period July to October when the pelagic fishery is closed. Reef fish however may be captured all year round at some sites. This is a fishery that is believed to be over fished especially along the south and west coasts where fishermen have reported reduced catch per unit effort and fish sizes. (Fisheries Division 1997)

The deep slope fishery targets mainly snapper and grouper and is active during July to October when the availability of large pelagic declines. This is believed to be an under-exploited resource and research in this fishery has been recently started by the Fisheries Division. It is felt however that as a fishery it is also sensitive to over-exploitation. (Fisheries Division 1997)

The coastal pelagic fishery occurs mainly on the west and south coasts targeting Jacks, (Carangidae), Herring (Clupeidae), Silver Sides (Atherinidae), Ballyhoo (Heruiramphus sp.), and Robins (Derapterus sp.). There is currently little known on the resources of this fishery. Much of this fishery is used for bait although some are used for sale. (Fisheries Division 1997)

The other fishery type constitutes the offshore fishery where the large oceanic pelagic are exploited eg. Tuna, Wahoo Billfish, Swordfish, Dolphin, Mackerels and Flying Fish. These are not discussed here.

4.2.2 Non living resource exploitation{tc \l3 "4.2.2 Non living resource exploitation}

The principle non living resource exploited in the coastal area are the sandy beaches and associated nearshore which are used by the residents and popular with the tourists for swimming and bathing. In general the beaches are suffering from varying levels of development encroachment which is having a direct effect on the ability to use and to gain access to the area. There is no commercial exploitation of beach sand in Barbados.

4.2.3 Aquaculture{tc \l3 "4.2.3 Aquaculture}

Aquaculture is not significant in the coastal areas of Barbados. There are currently three locations where it occurs, two on the north of the island (St. Lucy) and one on the east of the island (St. John). Currently two of the projects concentrate on the growth of sea moss (the east coast location and one location on the north coast). The Half Moon Fort, St Lucy location is operated by a private individual while the Consett Bay, St. John location is operated by a community group from the area.

The other northern site also located at Half Moon Fort is a commercial mariculture nursery for the Caribbean Red Drum - a fish found in the Gulf of Mexico. This species is currently being raised from embryo through to fingerlings and these are sent to the larger aquaculture facilities of the company in Martinique and Guadeloupe for their grow out and sale.

Currently there are negligible impacts from these facilities. The Government has ensured that the locations chosen to site these projects are in areas that best meet the planning requirement for these sort of developments.

The Fisheries Division is currently in the process of developing a policy on aquaculture (both terrestrial and marine) which will specify the sort of projects that can be developed. It is proposed that associated with this policy, will be the development of new legislation in the form of regulations to the Fisheries Act to specifically address the issues of aquaculture.

4.3 Climate Change and Natural Disasters{tc \l2 "4.3 Climate Change and Natural Disasters}

- **Impact of sea level rise on the coastal areas**.

At present Barbados has not been able to determine if it has experienced the effects of sea level rise on coastal areas. This is primarily because there is no long term tide gauge data available for Barbados. The estimated rate of sea level rise has been inferred from geological, geomorphological and oceanic

evidence. The problem has been further complicated because of crustal emergence estimated at a rate of 0.3m/1000 years (Nurse 1989). Estimates to date suggest a mean sea level rise of approximately 0.6 mm/year (Bird 1982). Even at this rate it can be expected that given Barbados' narrow gently sloping beaches significant effects could be experienced. The coasts to be worst affected could be those that support the greatest building infrastructure. Were this to occur, it could also be expected that there would be evidence of the increased effects of beach erosion, a higher incidence of flooding of the sand terrace and coastal plain, causing damage to infrastructure and property. This is significant since at present the coastline of the west and south coast house more than 60% of the island's population within a narrow 2 km band.

· **Impacts of extreme weather occurrences on the coastline**

While Barbados has not experienced a direct hit by a tropical cyclone since 1955, the coastline has on an almost annual basis experienced storm waves and high sea swells generated from, tropical depressions, storms and hurricanes which have passed within the vicinity of Barbados.

In all cases extensive damage was experienced on the island's beaches with thousands of cubic meters of sand being lost from some locations to deep water. This has especially been the experience on the east coast beaches, where the shelf is very close to the shoreline. The erosive effect of these storm waves on the west and south coasts, has contributed the continued and progressive narrowing of these beaches, the loss of sand to deep water, the deposition of coral rubble in the nearshore at some sites and extensive damage to coral reef ecosystems.

The resulting property damage has also been apparent with several properties frequently having their property guard walls destroyed and some properties being damaged by foundation undermining, flooding and the loss of landscaped areas. Those properties built too close to the high water mark frequently experience the full force of the storm waves in such instances.

As a result of the property damage experienced, property owners frequently resort to placing boulder/armour stones on their sea frontage. This reflects wave energy at the front of the property and prevents the natural return and deposition of sand, when normal wave conditions return. As a direct result of the use of inappropriately designed and constructed shoreline protection works several segments of the Barbados west and south coasts are eroded to a condition where they cannot recover (ie the structure is now in the sea, and adjacent areas are in a stable to eroding condition).

· **Disaster Preparedness and Climate Change**

The Barbados Central Emergency Relief Organization (CERO) is responsible for all disaster preparedness and management on the island. There is a National Disaster Preparedness Plan as well as subsidiary plans to deal with flooding from terrestrial sources, major accidents, hurricane preparedness etc.

The Hurricane Disaster Preparedness Plan is put into preparation prior to the hurricane season (March - April) and is activated at the beginning of every hurricane season with a one week symposium for all Government and private sector agencies involved in the plan, to ensure that all agencies with clear responsibility for certain aspects of the plan are at or near a state of preparedness for the hurricane season. In doing this, it is hoped that should Barbados suffer the damage effects of a hurricane, all agencies involved will be clear in their immediate role and responsibilities.

With regard to climate change, the Government has been involved for the last three (3) years in the Caribbean Planned Adaptation to Climate Change Project. Barbados is especially interested and involved in the components that deal with the monitoring of sea level rise, coastal vulnerability assessment and economic valuation of coastal resources.

At this time there has been some general work developed on the potential storm surge inundation line that could affect the west and south coast. This has provided generic information allowing for the identification of the extent of flooding that could occur in the passage of a 1 in 100 year storm event combined with an astronomical high tide and storm surge.

The Coastal Zone Management Unit (CZMU) has installed two (2) tide gauges (1 east coast, 1 west coast) to monitor tides around the island. The Unit has supplied tidal information to the Permanent Service for Mean Sea Level (PSMSL) and intends to become part of the Intergovernmental Oceanographic Commission Global Sea Level Observing System (GLOSS).

The CZMU is also in the process of developing guidelines for incorporation into the construction design of coastal properties that may fall within the inundation line, to reduce the effects of coastal flooding on the property.

· **Flooding Impacts on the Marine Ecosystem**

Flooding results in the high volume and high velocity discharge of terrestrial runoff into the nearshore environment. The resulting effects on the marine environment have been previously described.

Additionally, there is a serious issue of the transportation and deposition of litter, garbage and debris (natural and man made debris) in the marine environment. These forms of garbage frequently are illegally disposed of in gullies and water courses and are only observed if the flooding event is significant enough to transport them to the coastline.

· **Development Practices which contribute to threats to life and property**.

Development has always occurred and will continue to occur along the island's coastline. There are some development practices currently performed by property owners, which can contribute to the demise of their property. They are:

(i) building too close to the High Water Mark position on the beach;
(ii) not conforming to stipulated condition for which permission for development was granted;
(iii) performing illegal developmental works prior to receipt of planning approval;
(iv) constructing poorly designed property protection structures.

In each case it is a violation of the Town and Country Planning Act and while the property owner and developer may feel that he is "addressing a problem which is directly affecting his property", he may be also contributing to, or compounding an existing problem, not only for himself but for his neighbours.

The worst threats to property from development practices are:

(i) Constructing a building in the active beach zone. This reduces the natural buffer effect of waves on the beach and in times of high energy storm waves reduces the actual surface area on the beach available for the waves to expand their incoming energy. In such cases, the wall, fence or even building can be extensively damaged.

(ii) Constructing poorly designed sea defense structures in an attempt to prevent property damage. This results in the structures, which are built destabilizing the shoreline with long-term effects downstream of the structure or in the immediate vicinity of the structure.

In both cases given the current planning legislation it is very difficult to have such works removed from the property. However there is a legal procedure to be followed in order that any such works can be removed.

Development practices, which can threaten life, can be included in those identified above, as a property too close to the sea in a storm or hurricane can be in danger of threatening life.

Additional concerns of this nature include, properties built along the (i) the edge of cliff tops with inadequate setbacks; (ii) the top edge of water courses or (iii) in coastal flood plains where there is inappropriate drainage. In such cases the properties are at the mercy of the effects of wave overtopping in the first example and for the other example the flood waters as they move along the water course, and the effects of subsidence of the banks and sides of the water course as a result of their saturation.

Poorly placed engineering structures along a coastline also pose a potential hazard in that they may block lateral access along the shoreline and as persons climb over them they may suffer injury from incoming waves. In the case of using gabions on the beach, when the gabion baskets corrode and their contents are dispersed on the beach, the exposed rusty wire poses a health hazard and public nuisance that as they can buried in the sand, and yet inflict injury to persons using the beach area.

4.4 Transboundary Threats{tc \l2 "4.4 Transboundary Threats}

Due to its isolation as an island there are no transboundary threats to its coastal areas.

4.5 Land based Pollution{tc \l2 "4.5 Land based Pollution}

At present the sources and activities of land based pollution are having cumulative impacts on coastal area management. The primary effect is seen through the increased stress being placed on nearshore fringe reefs and to a lesser extent sea grass beds. These activities are contributory in there effect through the deterioration of the nearshore water quality as a result of nutrient loading from non-point pollution sources (surface water and ground water discharge/runoff), sedimentation and to some extent solid waste being deposited in the nearshore as a result of wash down from water courses.

The effects of sedimentation resulting from poor agricultural practices and the clearing of the walls of gullies and water courses frequently results in the suspension of high concentrations of sediment in water flowing through water courses and gullies or flowing from agricultural fields into drainage walls or nearby culverts and drains which make their way to the coasts.

4.6 Tourism{tc \l2 "4.6 Tourism}

The major tourism concerns related to coastal area management focus primarily on being able to effectively utilize the available land area for the best economic gain based on the type of tourism infrastructure proposed for the site. Given the current laws regarding coastal development and the effective use of coastal space for tourism purposes, the use of the shoreline is favoured for tourism. Issues of concern from the tourism perspective specifically relate to user conflict zoning as relates to watersports (jet ski and other power craft sports), and passive recreation (swimming and bathing) in the nearshore; the lack of appropriate public facilities at some beaches; and the quality of the bathing waters along the coast at some sites.

The major impacts from tourism are those related to effluent loading in the sheetwater lens at the coastline, building too close to the high water mark and therefore destabilizing beaches contributing to erosion and the construction of inappropriately designed and coastal engineering structures which can contribute to beach erosion. In this latter case it is often the case that such coastal protection works are built without going through the correct Town and Country Planning Department process.

4.7 Health{tc \l2 "4.7 Health}

The major health concerns related to coastal area management are the control of activities that can potentially impact on water quality. In this respect there is a national coastal water quality monitoring programme in place to monitor the bacterial and chemical quality on a monthly basis at the more popular recreational beaches around the west and south coasts. This is carried out by the Environmental Engineering Division of the Ministry of Health and the Coastal Zone Management Unit of the Ministry of Environment, Energy and Natural Resources. This monitoring programme of the coastal water is done to ensure that the water quality is in compliance with international standards of WHO and the USEPA, for recreational bathing waters.

There are no major food safety concerns linked to coastal areas, as Barbados does not currently have a major shellfish fishery. However the reef fishery has been prone to periodic episodes of 'fish kills'. The last such event occurred in October 1999 and has been traced to a large body of fresh water originating from the Amazon Basin in South America. This movement of this large freshwater body not only affected the reef fish fishery of Barbados but several of the other Caribbean islands as well. During the fish kill episode, there was a curtailment in the consumption of all fish nationally, which affected the entire fishing industry and not just the reef fish fishery. After the 'all clear' was given on the fish kill, it took several months for the public to actually return to consuming fish as part of their daily diet.

4.8 Data, Information, Management and Research{tc \l2 "4.8 Data, Information, Management and Research}

The Coastal Zone Management Unit has been the primary agency involved in the monitoring programmes for collecting data on coastal areas. It has been performing beach profiles at over 100 profile sites around the island since the late 1980's. Over the years the data collection capability of the Unit has been systematically improved and expanded to include tidal monitoring, wave monitoring, marine ecosystem monitoring (mainly the fringe and bank reefs for coral health, abundance and diversity and within the last 2 years coral disease monitoring).

The available equipment include surveying equipment, a Total Station and range poles, GPS backpack receivers, a GPS base station located at the Unit's office, dive equipment and reef monitoring equipment, wave recorders, tide gauges, and hydrographic surveying equipment.

No external data support is currently utilized. The main systems used for capturing data are spreadsheets and software packages designed to help provide decision support information for Coastal Zone Management. These include the use of:

- Geographic Information Systems - ArcCad and ArcView
- Shoreline Management Software - SANDS (Shoreline And Nearshore Data Systems)
- Coastal Engineering Models - for assessing the potential impacts of engineering structures on the coastline and how the impacts can be mitigated.

The data collected in all the monitoring programmes is of a primary nature. Quality control is performed on all data entering the systems as required. However the regularity with which the data is updated in the system is a concern.

The areas of resource assessment, research, training, and public education have generally neglected. Over the last 3 years the Coastal Zone Management Unit has embarked on a small scale public education programme, however it needs to be further expanded. In general, most of the resource assessment and research has been done through the use of international consultants as part of the phased Coastal Conservation Programme for Barbados. This has been done since the Unit's inception in 1983 at varying intervals. Currently additional human and financial resources need to be provided in order to improve coastal area management. Some major areas of research needs are

- modelling of nearshore current pattens

- evaluation of climate change on coastal resources and coastal management
- development of a zoning plan for the recreational use of the shoreline to reduce user conflicts
- improving the wave monitoring around the island
- determination of meteorological parameters for monitoring
- coastal water quality trends.

4.9 Stakeholder Participation/Awareness and Evaluation{tc \l2 "4.9 Stakeholder Participation/Awareness and Evaluation}

Several approaches have been initiated by the Coastal Zone Management Unit and are ongoing in relation to coastal area management. These include:

- Presentations to specific target groups by the Unit's personnel (i.e primary and secondary schools, tertiary institutions, church groups; NGO's eg. Barbados National Trust, Rotary Club, Barbados Hotel and Tourism Association; Government Departments, Planning and Priorities Committee - a sub committee of Cabinet; Trade Unions, teachers and community groups).
- Production of a newspaper supplement on coastal area management and the development of the coastal zone management plan for the island.
- The development and implementation of community led demonstration projects as part of the Coastal Conservation Programme Phase 1 Study to promote sustainable coastal area management through community involvement. These include the development of a coastal trail, research into the user conflict use of a watershed area, shoreline revegetation and options for low cost, dune stabilization, mariculture of seamoss, the co-management of the sea urchin fishery. Other projects outside of that study included: the development of a community led protected area for marine turtles and the development of a marine park.

Some of these activities have been closely monitored and have shown to be successful through the project cycle. The Unit has maintained its commitment to the projects in the form of financial and personnel support after the project completion. In some cases the interest in the project by the communities has failed after the project completion, however in others, the project are continuing. It should be noted here that there is a high awareness at the level of the public regarding the issues that can affect coastal resources and that the public do not often like to feel alienated from such resources.

- Use of skits on TV
- Open days at the Coastal Zone Management Unit with glass bottom boat rides to unique reefs and wrecks close to the office.
- Participation in radio call in programmes.
- Participation in Town Hall and other public meetings and panel discussions.

In general there has been little public participation in the general decision making process for coastal area management. The input of the public has been primarily sought during the conduct of studies and in the development of the Integrated Coastal Zone Management Plans for Barbados (1998 and 1999). There is need to have a further comprehensive review of some of the activities that have been initiated at the community level by communities to determine their success or failure.

Within the last 2 years there have been other related projects in coastal area management that have fallen outside of the mandate of the Coastal Zone Management Unit but still within the preview of its parent Ministry. These projects have had a strong community and stakeholder participation focus, which resulted in the establishment of 'a stakeholder round table'. This group was integrally involved in the execution of the project components and helped develop the final product, which was acceptable to all round table members. The recommendations have been presented to the Government and are under consideration at this time.

There have been no specific programmes specifically designed to recognize the importance of gender in coastal area management.

4.10 Institutional Framework{tc \l2 "4.10 Institutional Framework}

The Coastal Zone Management Unit is the governmental unit in the Ministry of Environment, Energy and Natural Resources with the mandated responsibility for coastal zone management in Barbados. This mandate was enabled through the Coastal Zone Management Act 1998. Since its inception in 1983, the Unit had always informally possessed the mandate to deal with certain coastal area management issues. This resulted in the unit only providing an advisory role and service in several key aspects of coastal management. With the passage of the Coastal Zone Management Act clear legal areas of responsibility have been assigned to the Unit to provide for the effective management of the coastal areas of the island. The Act empowers the Director, Coastal Zone Management Unit to

- provide advice on the policy to be adapted in respect to coastal management
- enforce the Coastal Zone Management Act
- recommend to the Minister, Public Officers to be designated to discharge the function of Coastal Zone Inspectors.
- ensure the best use, conservation, and protection of the coastal areas.

Further the several subsections of the Act allow for specific measures to be developed to deal with issues related to

- designation of protected marine areas
- coral reef protection
- beach protection
- development of a coastal zone management plan for the island.

While the Coastal Zone Management Act has been enacted recently there is still a need to develop the regulations to go to assist with the enforcement of some key components of the Act. The CZMU will be working on developing these regulation within the next 2 years.

A summary of the other agencies that have major roles in coastal area management are shown in Table 5.

Table 5: Organizations Involved in Integrated Coastal Management{tc \l1 "Table 5: Organizations Involved in Integrated Coastal Management}

Ministry	Organization	Main CZM Function
Ministry of Environment, Energy and Natural Resources	Coastal Zone Management Unit	oceanographic assessment, coastal research, engineering, development control on the coast and education
	National Conservation Commission	Operation of beach and park facilities, provide advice on coastal rehabilitation and provide life guard services
	Environmental Unit	Provide advice on policy and research, education planning and environmental impact assessment.
Ministry of Health	Environmental Engineering Division	Development approval for pollution monitoring and enforcement
	South and West Coast and Greater Bridgetown Sewerage	Study design and construction of sewerage collection, treatment and outfall works
	Sanitation Services Authority	Solid Waste Collection and Disposal
Ministry of Public Works	Drainage Unit	Design and construction of marine structures, dredging and maintenance of coastal culverts, wells and drains.
Division of Housing	Property Management	Management of crown lands in the coastal zone.
	Lands and Surveys	Definition and determination of land boundaries.
Ministry of Foreign Affairs, Tourism and International Transport	Barbados Port Authority	Operation of Habours, Terminals, Marinas, safety and pollution in territorial waters. Marine affairs regulation of shipping
Ministry of Finance and Economic Affairs	Town and Country Planning Department	Development approvals, control and compliance in the coastal area.
Ministry of Agriculture and Rural Development	Fisheries Division	Sport and commercial fisheries management and regulation
	Soil Conservation Unit	Soil conservation and agriculture pollution management in the Scotland District
	Analytical Services Laboratory	Laboratory analysis
Defence and Security Division	Police Department and Barbados Defence Force	Policing and enforcing regulations set for use of the sea.

From this it is clear that there are substantial pieces of associated legislation that relate to different policy aspects of coastal area management. The fragmented nature of the legislation was one of the driving forces behind the development of the Coastal Zone Management Act i.e. the need to harmonize the legislation to identify where major legislative gaps existed and have a comprehensive legal instrument to deal with coastal area management issues. The major policy framework is contained in the policy framework for Integrated Coastal Zone Management for Barbados (Halcrow 1998) which was approved by the Government of Barbados in 1999. This was prepared by a team of consultants as well as government technocrats as part of the Coastal Conservation Programme Phase 1 Study. The document sets out the following broad policy areas and how they can be achieved *inter alia*:

- sustainable use of the coastal zone management area by implementing policies, which maintain and where possible enhance environmental quality while enabling economic development.
- To seek compatibility between economic activity and environmental interest at the coast.
- To conserve, enhance and where possible restore the quality of the coastal environment.

As stated earlier, the Coastal Zone Management Unit is a government department, hence it receives all its finances from the Government. Major projects that constitute the phases in the island's Coastal Conservation Programme are financed by loans and to a lesser extent grants (depending on the nature of the project component) secured by the Government from international funding agencies. It was not possible to ascertain the investments made in the sector.

Currently it is difficult to determine the level of skills available in coastal area management in the country due to the fact that the majority of coastal area management activities are carried out by the Coastal Zone Management Unit. With the enactment of the Coastal Zone Management Act, the Unit has been given an increased mandate and has found itself being drawn into areas where there was previously a void, or having a coordinating role in dealing with agencies whose legislation may allow them some degree of regulatory action. However, there is no inventory of available expertise nationally. The Unit recognizes that there are several private sector engineering firms that have worked previously in the coastal area throughout the region; there are trained physical and urban planners in the private sector that are aware of development issues in coastal areas; and there are scientists and environmentalist in the private sector with high levels of training in various disciplines that can have a direct bearing on coastal area management.

The Coastal Zone Management Unit currently has on its technical staff the following qualified personnel: one coastal geomorphologist, three marine biologists, one coastal engineer, one civil engineer, one geographer, one hydrographer and two biologist one of whom is completing post graduate studies in marine park management and planning.

As part of the phased approach to coastal conservation, Barbados has attempted to ensure over the years that local consulting firms have an opportunity to collaborate as part of the project management process with the foreign firms contracted to carry out the project. This ensures that at the private sector level there is involvement, exposure and some technology transfer in the current trends in coastal area management. Additionally the CZMU has benefited from in-house counterpart training with the foreign consultants, together with having staff being sent overseas for postgraduate training in specific areas of coastal area management to improve the functional efficiency of the Unit.

It can be agreed however that given the expanding mandate of the CZMU there is currently a general lack of adequately trained manpower within the CZMU and other agencies, due to inadequate remuneration, failure to retain qualified staff and a corresponding lack of a structured training programmes.

5.0 INTEGRATED WATERSHED AND COASTAL AREA MANAGEMENT{tc \l1 "5.0 INTEGRATED WATERSHED AND COASTAL AREA MANAGEMENT}

5.1 Problem Identification{tc \l2 "5.1 Problem Identification}

5.1.1 Legal and Policy Framework{tc \l3 "5.1.1 Legal and Policy Framework}

It is well recognised that land-based activities and pollution sources can impact both the watersheds and coastal areas. However, what does not seem to be fully appreciated are the processes involved and the interrelationships between the land-based watershed and coastal area management and control measures and practices. For example, soil erosion control measures adopted to mitigate against potentially negative impacts on the watershed and water resources will also directly benefit the coastal areas due to the reduced sediment load that will reach the sea. With the advent of desalination the coastal area indirectly becomes a watershed area that needs to be protected to protect the seawater intakes. In addition, surface runoff is currently treated as a drainage or flood nuisance, which should be removed from the land and allowed to run into the sea if possible. If it were instead considered a potential water resource, and the need to protect the coastal areas was factored in, then measures taken to detain this resource within the watershed, could potentially benefit both systems and vice-versa. Secondly, the costs for mitigation measures adopted could be spread over the benefits accruing to both the watershed and the coastal areas.

However, the existing policy and legal provisions as well as institutional capacities are inadequate to facilitate and formally endorse an integrated approach, partially due to the sector or problem specific approaches taken in developing the policies and institutions. Whereas informal coordination and consultations do take place between various agencies, in some cases, there is no formal requirement to do so, in which case, the overriding interests of the project developer or the implementing agency prevail.

For example, the recently enacted Marine Pollution Control Act, 1998-40 is intended to prevent, reduce and control pollution of the marine environment of Barbados from whatever source. It does not however, formally require the Director responsible for enforcing the Act, to consult with or ensure that measures taken to reduce potential pollution of the marine environment will not negatively impact the watersheds. No provision has been provided in the Act to appeal against this. It is also not clear whose authority would prevail, for example, in setting the allowable pollutant levels, if the levels set by the Director of the Marine Pollution Control Act were to be objected to by the watershed manager. Furthermore, no procedure is outlined for resolving such a problem.

There are however, two documents or provisions that may help induce an integrated approach to watershed and coastal area management. One such document is the National Sustainable Development Policy Framework produced by the National Commission for Sustainable Development (NCSD). This document is still at draft stage, but takes a holistic approach to addressing all the issues, with broad consultation and participation of the stakeholders. However, it must be noted that the NCSD is only and advisory body and its recommendation may not be accepted.

The second provision comes from the recommendations of the just concluded Environmental Management and Land Use Planning Project (EMLUP). The relevant recommendation relates to the amendment of the Town and Country Planning Order to require all major development projects to conduct Environmental Impact Assessments (EIA) as one of the conditionalities for approval. Due to the broad spectrum of the composition of the EIA Review Committee that can be formed by the Chief Town Planner, it is envisaged that an integrated management approach will result.

There is therefore a demonstrated need to enhance and harmonise the existing body of legal and policy provisions to facilitate and ensure an integrated approach to watershed and coastal area management.

Instruments, which clearly and unambiguously allocate responsibilities for enforcement, monitoring, compliance and consultation for all environmental matters, should be developed and adopted.

5.2 Institutional{tc \l2 "5.2 Institutional}

A number of institutions currently exist with varying mandates to deal with watershed and coastal areas. These include the Barbados Water Authority and Drainage Unit, Ministry of Public Transport Communications and Works the Water and Land Use and Soil Conservation Units of the Ministry of Agriculture, the Environmental Engineering Division of the Ministry of Health and Coastal Zone Management Unit of the Ministry of the Environment, Energy and Natural Resources. There are currently no well established NGOs or private sector groups involved.

What is therefore needed is the development of an institutional framework and capacity to facilitate the consultation and participation of the relevant stakeholders that are needed to achieve an integrated approach to watershed and coastal area management.

5.3 Financial{tc \l2 "5.3 Financial}

An integrated approach would minimise duplication and help set priorities for allocation of financial resources. Mitigation costs would be spread out over the relevant beneficiaries and better estimates of cost/benefit ratios would result. Better value for money is expected especially in light of Barbados decreasing access to grant money and low interest loans.

5.4 Intended Goals{tc \l2 "5.4 Intended Goals}

5.4.1 Legal and Policy Framework{tc \l3 "5.4.1 Legal and Policy Framework}

A major goal of the integrated watershed and coastal area management approach should be the harmonisation and/or enhancement of the legal and policy provisions, to eradicate duplication and plug the loopholes that currently exist because of policies that are sector specific. Policies and legislation to facilitate an integrated approach are needed.

Another goal is that with the harmonised and enhanced legislation and policies better enforcement, monitoring and compliance will result. Additionally adoption of an integrated approach will help bring Barbados in line with a number of international declarations and agreements, to which it is a signatory.

5.4.2 Institutional Framework{tc \l3 "5.4.2 Institutional Framework}

Every single study done in both sectors has indicated the need for institutional strengthening and capacity building. An integrated approach should see the development of an overarching institutional framework from which the sector specific institutions can then be curved out with little or no duplication of responsibilities or capacities. With this should come the identification and formalisation of a structured framework for allocation of responsibilities and consultation with and among the relevant stakeholders.

Currently, except for the enforcement of the groundwater protection zoning policy and the newly introduced EIA consultation process, there is no structured framework and requirement to consult with other agencies or stakeholders.

Socially the major goal should be the change from "the government will provide concept" to one where the government will facilitate and provide protection in the public interest by ensuring equitable distribution, allocation and utilisation of the resources. This would facilitate greater participation of the other stakeholders in the management of the watersheds and coastal areas.
Recent attempts at stakeholder participation have stopped short of involving them in management. This may be due to the fact that the largest water abstracter the BWA is also the licensing and regulatory agency as well as the watershed manager. One of the goals should therefore be to create institutions that do not have a potential conflict of interest.

5.4.3 Financial Framework{tc \l3 "5.4.3 Financial Framework}

The adoption of an integrated approach should see the joint preparation and presentation of projects or proposals for funding and better prioritising of projects, which can then be done in phases with a very clear understanding of the final outcome and interactions between projects. Joint proposals or solicitations for funding could be facilitated through central government and the costs shared among the participating stakeholders in ways that allow for the common goals to prevail rather than that of the implementing agencies. Economic instruments can also be used to ensure that the common goals prevail.

5.5 Barriers{tc \l2 "5.5 Barriers}

5.5.1 Legal and Policy Framework{tc \l3 "5.5.1 Legal and Policy Framework}

A large body of legislation and policies exist but there are no overarching legislation or policies to facilitate an integrated approach. In addition, the level of awareness for the need for an integrated approach is very low even among the technocrats involved in the sector. Unless this level of awareness is raised, it is unlikely that the appropriate legislation or policies will be developed.

5.5.2 Institutional Framework{tc \l3 "5.5.2 Institutional Framework}

It is clear that inspite of the many institutions in place the existing institutional framework and capacities are inadequate and inappropriate for the adoption and implementation of an integrated watershed and coastal area management approach.

Currently major research and development projects in watershed management are undertaken by the BWA who may see an integrated approach that includes coastal areas as indirectly eroding their powers and since the responsibilities fall under two different ministries, conflicts in reporting arrangements may arise. Similar conflicts may arise in relation to capacity building and allocation of resources. Inspite of the challenges arising out of overlapping and duplication of some responsibilities between various agencies, and the lack of institutionalized coordination to minimise these conflicts, the major constraints seems to be: the lack of adequately trained manpower to carry out these functions; and a lack of structured training programmes.

Current use of information and decision support systems in watershed management is still very limited. This could become a stumbling block to an integrated approach where more information may be generated.

5.5.3 Financial Framework{tc \l3 "5.5.3 Financial Framework}

Currently the BWA does not receive any funds from central government for its daily operations but the government obtains funds or loans from international or regional funding institutions on BWA's behalf. However, CZMU is a government agency and therefore gets all its money through government. Unless this situation is harmonised management conflicts could arise unless both activities are brought under one umbrella.

Inadequate financial compensation to attract and retain qualified staff is another barrier to the implementation of capacity building programmes and new information and decision support systems.

6.0 NATIONAL ACTION PROGRAMME TO IMPROVE INTEGRATED MANAGEMENT OF WATERSHEDS AND COASTAL AREAS{tc \l1 "6.0 NATIONAL ACTION PROGRAMME TO IMPROVE INTEGRATED MANAGEMENT OF WATERSHEDS AND COASTAL AREAS}

6.1 Legal and Policy Framework{tc \l2 "6.1 Legal and Policy Framework}

As a first step to the development, harmonisation and/or enhancement of the legislation and policy framework needed to facilitate an integrated approach to integrated watershed and coastal area management, the recommendations contained in the Draft National Sustainable Development Policy paper prepared by the National Commission for Sustainable Development (NCSD) should be reviewed. This may provide the basic framework for the establishment of an overarching legal and policy framework, since the NCSD looked at all activities that may impact the environment.

If the NCSD policy paper is deemed to be supportive of and necessary for the implementation of an integrated approach, then its adoption by Cabinet should be advocated for.

In the absence of the necessary legal and policy provisions, then the informal approach of using steering committees should be promoted until the necessary legislation and policies are implemented.

6.2 Institutional Framework{tc \l2 "6.2 Institutional Framework}

The Barbados Water Authority (BWA) and Drainage Unit (DU) of the Ministry of Public Works and Transport, the Water and Land Use and Soil Conservation Units of the Ministry of Agriculture, the Environmental Engineering Division (EED) of the Ministry of Health and the Coastal Zone Management Unit (CZMU) of the Ministry of the Environment, Energy and Natural Resources are all currently involved in watershed and coastal area management. Institutional provisions have to be made to facilitate greater participation of all stakeholders.

The major players, however, are the BWA, EED and CZMU. It is clear that with the advent of the Marine Pollution Control Act, which is to be administered by the EED, the EED institutionally needs to collaborate and consult very regularly with both the BWA and CZMU, the two major watershed and coastal area managers. This informally forms the most obvious starting point for collaboration towards an integrated approach in the absence of an overarching institutional framework. The first approach could therefore be to ensure that this collaboration is properly structured and formalised. The sharing of expertise from the three institutions would also help to provide the capacity needed for immediate implementation of the Act, before formal capacity building requirements are reviewed and implemented.

To facilitate and enhance watershed management, the present conflict of interest arising out of the arrangement whereby the BWA is the major water abstractor as well as licensing and regulatory agency and watershed manager, should be resolved. This will allow for better delivery of the regulatory and watershed management functions. This separation of responsibilities has been accepted by government, which is now attempting to identify and implement the most appropriate institutional arrangement. In this regard, integrated watershed and coastal area management institutional framework requirements should be taken into consideration.

6.3 Financial Framework{tc \l2 "6.3 Financial Framework}

It is clear that an integrated approach could result in potential financial savings due to the potential reduction in duplication of projects and institutional capacities. This approach is also helpful in identifying the priorities in terms of allocation of financial and other resources due to the proper identification and staging or phasing of projects that may arise out of a joint or integrated development of projects for the two sectors.

Action to adopt integrated approaches to resource management will also bring Barbados in line with approaches being advocated by the international funding agencies such as the World Bank and Inter-American Development Bank, in order to receive funding from them.

List Of Recommended Actions

ACTION	EXECUTING AGENCY	
Adoption of Integrated Watershed and Coastal Areas Management Policy	Ministries of Environment, Public Works and Agriculture.	Short-term
Development and Implementation of Demonstration Project	Ministries of Environment, Public Works (Barbados Water Authority and Drainage Unit) and Agriculture.	Short to Long-term
Harmonise legislation with respect to policy and management of natural resources (i.e. implement relevant EMLUP recommendations) taking into account the draft Policy Frameworks for Water Resources Development (BWA), Sustainable Development (NCSD), Drainage and Agriculture	Ministry of Environment, Energy and Natural Resources, National Commission for Sustainable Development (NCSD)	Short to medium term
Modify Drainage Act to consider surface water runoff as a resource rather than a nuisance and to consider impact on watershed and coastal areas.	Ministry of Public Works and Communication	Short-term
Develop overarching Institutional Framework for Sustainable Development	Ministry of Environment, Energy and Natural Resources, National Commission for Sustainable Development (NCSD)	Short to medium term
Provide Resources for full Implementation of Marine Pollution Act	Ministry of Environment, Energy and Natural Resources	Short, medium and long-term
Develop regulations to facilitate enforcement of Coastal Zone Management Act	Coastal Zone Management Unit (CZMU)	Medium term
Assess level of skills available in Water Resources and Coastal Zone Management in the Country and prepare capacity development plans.	All relevant agencies	Short to medium term
Repeal Porey and Three Houses Spring Acts.	Attorney General's Office	Medium term
Draft and enact legislation to support above policies, the Groundwater Protection Zoning Policy and clarify water rights.	Attorney General's Office	Medium term to long-term

It is clear from previous experiences that unless the Integrated Watershed and Coastal Areas Management

policy is formally adopted by the relevant agencies and supported by a structured implementation mechanism similar to that suggested for the development and conduct of Environmental Impact Assessment (William & Shier et. el., EMLUP studies), agencies may choose to apply it only selectively, when it suits them. The BWA is currently involved in the implementation of an Integrated Water Resources Management regional project sponsored by the Organisation of American States (OAS) and Caribbean Science and Technology Council and executed by Trinidadian National Institute for Higher Education, Research, Science and Technology (NIHERST). One of the activities to be carried out is the harmonisation of the BWA's Draft Policy Framework For Water Resources Development and Management, the NCSD's Draft National Policy Framework for Sustainable Development and the Ministry of Agriculture's Draft Agricultural Development Policy Framework. In addition, a review will be done to ensure compliance with international and regional obligations.

It was noted in developing the NCSD's National Sustainable Development Policy Framework that the NCSD lacked authority to enforce the proposed policies and that an institutional with overarching powers and framework was needed. The need for such an institution was therefore recommended in the Draft Framework and it is hoped that this will be accepted by government and that the NCSD will be such an authority.

The development of regulations to assist in the enforcement of the Coastal Zone Management Act is expected to be conducted by the Coastal Zone Management Unit over a two (2) year period and the government is currently in the process of selecting Consultants to help train staff of the Environmental Engineering Division (EED) in the implementation of the Marine Pollution Act.

The assessment of skill levels, repeal of Porey and Three Houses Acts as well as the enactment of supportive legislation even though priority items, may not be seen as requiring immediate attention since most of the attendant skills are currently resident in the government agencies. In addition, there is some available legislation although scattered in various ministries The majority of the funding for these actions will come from central government.

7.0 RECOMMENDED INPUTS TO REGIONAL ACTION PROGRAMME{tc \l1 "7.0 RECOMMENDED INPUTS TO REGIONAL ACTION PROGRAMME}

Inspite of the challenges arising out of overlapping and duplication of some responsibilities between various agencies, and the lack of institutionalized coordination to minimise these conflicts, the major constraints seems to be: the lack of adequately trained manpower to carry out these functions; a lack of structured training programmes and problems in procuring financial resources to overcome deficiencies in remuneration of the human resources involved and to fund data acquisition activities.

The available programmes that can readily be associated with water resources management are principally regional in nature. An MSc programme in Natural Resource Management is offered through the Faculty of Science and Technology, University of the West Indies, Cave Hill Campus, Barbados and covers various areas of water resources management either through the Core, Elective or Specialisation courses or through research projects. The emphasis of this programme at the moment is on water quality monitoring, sampling and analysis and can probably cover both watershed and coastal area management if requested.

The Caribbean Institute for Meteorological and Hydrology (CIMH) is a regional organisation headquartered in Barbados which offers diploma and certificate level programmes in meteorology and hydrology. It is recommended that full use be made of this Institute to provide the necessary training.

Caribbean Basin Water Management Inc. (CBWM) is a regional training programme with thirteen (13) participating water utilities within the Caribbean basin. Its main objectives are the provision of training on a regional basis for the employees of the participating water utilities with emphasis on a self-sustaining training delivery system and the development of a local "in-house" training capability within the utilities themselves. There are no scheduled training programmes, however, but training workshops can be arranged on specific areas of interest including water resources management. This is an agency with special interest in watershed management since most utilities in the Caribbean are also responsible for watershed management and should therefore be utilized to deliver some components of the training needed.

Due to the paucity of adequately trained manpower to develop the legislation and policies needed for an integrated approach and the common need across the region to make adjustments to the legislation and policies to make it consistent with the relevant international agreements, the development of model legislation is recommended. This would also help in standardising management practices within the region. This approach has been adopted for the development of drinking and wastewater standards, whereby the Caribbean Environmental Health Institute has been charged with this responsibility.

The Commonwealth Science Council has already developed a network for information exchange and collaboration (SIWIN) for SIDS. The use of this network, which already addresses issues of, integrated water resources management for integrated watershed and coastal area management is recommended and would be in line with the objectives of the developers of the network.

It is clear that the majority of the issues identified will be common to other islands as well. In this regard, regional inputs to regional action programme could include:

1. Recommendation for adoption of Integrated Watershed and Coastal Areas Management Policy at CARICOM level.
2. Development of appropriate training modules based on common training and research needs, to be implemented using the available regional institutions as part of the regular programmes, summer camps or special workshops (i.e. Groundwater modeling, Management and Control of Saltwater Intrusion, Impact of Agricultural Chemical Applications and other landuses on Water Resources and Marine Ecosystems, Impact of Climate Change on Coastal and Water Resources, Determination and regional transfer of hydrological, hydrogeological and

meteorological parameters, Water Source Protection).

3. Development of sample legislation for adaptation by participating countries.

4. Preparation of compendium of successful applications of IWCAM, both regional and international.

5. Support and utilisation of the Commonwealth Science Council's SIWIN for SIDS network. Barbados has already posted the Draft Policy Framework for Water Resources Development and Management and Stakeholder Workshop (1998) on the network.

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